INDIAN TEA ASSOCIATION

SCIENTIFIC DEPARTMENT

TOCKLAI EXPERIMENTAL STATION

ANNUAL REPORT—1958

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ANNUAL REPORT FOR 1958

DIRECTOR'S REPORT

H. FERGUSON—Director.

A. D. SWAN—Scientific Officer.

STAFF

Mr. D. J. Wood, Senior Biochemist left for the U.K. on 20th April, 1958 on retiral from service.

During the year appointments were made as follows: Dr. T. D. Mukerjea joined the staff in the Additional Officer Grade on 13th February, to take charge of the new Pesticide Testing Unit; Dr. A. R. Sen joined Tocklai in the Senior Officer Grade as Statistician on 12th March; Dr. I. S. Bhatia took over the post of Senior Biochemist, in place of Mr. Wood on 15th August.

Mr. H. Ferguson, Director, was in the U.K. on leave and duty during June and July, during which time Dr. Wight acted for the Director. Mr. N. G. Gokhale was in the U.S.S.R. during part of June and July as a member of a Government of India Delegation, which he was invited to join by the courtesy of the Tea Board.

Other Officers were absent on long leave during the year as follows: Mr. S. K. Dutta and Dr. G. M. Das on overseas study leave; Mr. A. D. Swan on normal overseas leave; Dr. D. N. Barua on long leave in India.

Mr. D. N. Borbora, Mr. S. K. Basu, Mr. N. C. Barua, Mr. K. C. Sarmah and Dr. P. C. Sharma had annual leave during the year and Mr. D. J. Gray was absent for six weeks on special leave.

The following officers had local leave during 1958: Dr. W. Wight, Mr. I. McTear, Dr. N. B. Chanda, Mr. J. M. Trinick, Mr. P. M. Glover, Mr. R. I. Macalpine and Mr. W. Hadfield.

Mr. H. Ferguson, Mr. N. G. Gokhale, Mr. J. M. Trinick, Dr. N. B. Chanda, Mr. S. K. Basu, and Mr. N. C. Barua required medical leave during the year.

Mr. W. G. L. Austin of Plant Protection Ltd., who was seconded to Tocklai to co-operate in various field trials, completed this assignment and left the Station on 26th May.

Dr. Roberts from the Association's Chemical Laboratory at Butlers' Wharf visited the Station during November, 1958.

The Senior Staff at 31st December, 1958 is listed below under Branches:

Directorate :

Director ...	H. Ferguson, B.Sc. (Hons)
Scientific Officer (H.Q.) ..	A. D. Swan, B.Sc. (St. A.).
Personal Assistant to the Director ...	J. H. Blair.
Maintenance Engineer ..	N. C. Barua.

Physico-Chemical Branch:

Senior Physical Chemist ..	N. G. Gokhale, B.Sc. (Bom. & Lond).
Assistant Physical Chemist	Vacant.

Botanical Branch :

Senior Botanist and Plant Physiologist ...	W. Wight, Ph.D. (Leeds)
Botanist & Selection Officer	M. J. Green, B.Sc. (Edin.)
Plant Physiologist ..	D. N. Barua, Ph.D. (Cantab).
Additional Officer ...	P. K. Barua, B.Sc. (Cal.).

Agricultural Branch:

Senior Agriculturist ..	S. K. Dutta, B.Sc., (Bom. & Wales).
Assistant Agriculturist ...	S. K. Basu, B.Sc.Ag. (Delhi), Assoc. I.A.R.I.
Agronomist ...	K. N. Sharma, B.Sc. Ag., M.Sc. (Banaras), Ph.D. (Mich.), Assoc. I.A.R.I.

Plànt Pathology Branch :

Senior Entomologist	...	G. M. Das, M.Sc. (Cal.) D.I.C., Ph.D. (Lond)
Mycologist	...	K. C. Sarmah
Pesticide Testing Officer	...	T. D. Mukerjea, B.Sc. (Alld.), Ph.D. (Lond.) Assoc. I.A.R.I.

Biochemical Branch:

Senior Biochemist	...	I. S. Bhatia, B.Sc. (Hons.), M.Sc. (Punj.) Ph.D. (J. H., U.S.A.)
Biochemist	...	N. B. Chanda, M.Sc. (Dac.), Ph.D., (Edin.).
Tea Taster	...	J. M. Trinick.

Engineering Development Branch :

Senior Research Engineer	...	I. McTear.
Research Engineer	...	D. N. Borbora, B.Sc. (Mining) (Banaras), M.Sc. (Eng.) (Lond.), D.I.C.

Statistical Branch :

Senior Statistician	..	A. R. Sen, M.Sc. (Luck), Ph.D. (N.C., U.S.A.)

Assam Valley Advisory Branch :

Senior Advisory Officer, Assam	..	P. M. Glover, M.B.E., B.Sc.
Senior Advisory Officer, Cachar	...	E. D. Heath, B.Sc. Dip. Ag. (Cantab).
Advisory Officer North Bank	..	D. J. Gray, B.A. (Cantab).
Advisory Officer	...	W. Hadfield, B.Sc. (Hons.).
Asst. Advisory Officer	..	P. C. Sharma, M.Sc. (B.H.U.). Ph.D. (Lond.), F.L.S. (Lond.).

West Bengal Advisory Branch:

Senior Advisory Officer	...	R. I. Macalpine, B.Sc. (Forestry).
Advisory Officer	...	W. J. Grice, B. A., Dip. Ag. (Cantab).
Asst. Advisory Officer	...	H. Mitra, B.Sc., (Cal.).

VISITORS

Visitors during the year from the Indian Tea Association and business houses connected with tea in London were as follows : Mr. H. C. Bannerman, of Macneil & Barry Ltd., and member of the I.T.A. London ; Mr. R. O. Hobhouse, Trustee of Meleng Tea Estate ; Mr. C. G. H. Thompson of the Assam Co. ; Mr. D. C. Hodson and Mr. R. G. Phillipp of James Warren & Co., Ltd. ; Mr. Evers of Thomas Cumberledge & Co. ; Sir Robert McLennan of the Scottish Assam Co. ; and Mr. E. C. V. Browne of Alex Lawrie & Co.

Members of the Indian Tea Association, Calcutta visited Tocklai to attend the 2nd and 3rd Quarterly meeting of the Scientific Department Sub-Committee and to attend the Conference, and are mentioned below under that heading.

Visitors from the Indian Tea Association Calcutta Staff and the Bengal Chamber of Commerce Staff included Mr. J. E. Atkins, Mr. T. J. Mathias, Mr. N. MacArthur and Mr. W. F. Joyce.

As usual a large number of visitors from the planting community and from Agency Houses visited Tocklai to seek advice, discuss problems, and acquaint themselves with the latest developments.

Some of the distinguished visitors other than the above are mentioned here in the chronological order of their visit : Dr. Klemme, Director of the Technical Co-operative Mission ; Dr. Puri of Lederle Laboratories (India) ; Mr. Peter de Jong of Tata Fison ; Mr. Parry-Jones, Director of Chesterford Park Research Station ; Major General W. H. A. Bishop, O.B.E United Kingdom Deputy High Commissioner, Calcutta : Mr. W. A. W. Clark, C.M.E., C.B.E., Acting U.K. High Commissioner, Delhi ; Mr. K. V. Kavanagh of Fisons Pest Control Ltd. ; Professor D. V. Ter Avanesyan and Mr. Pannikor of the U.S.S.R. Embassy, Delhi ; Mr. Gupta, Director of Telephones, Assam ; Mr. S. K. Banerjee and Mr. S. Janah of the Tea Board ; Mrs. Guha of the Social Welfare Board, Government of India ; Dr. Ramamurthi of Tata Fison Ltd. ;

Mr. Keegel and Mr. Kehl from the Tea Research Institute Ceylon ; Dr. Young of Rohm Hass and Co. Philadelphia, U.S.A. ; Dr. C. R. Harler of Messrs. James Warren & Co., Ltd. ; Mr. Turner of Shaw Wallace & Co., Ltd. ; Mr. Rihm of Chillean Nitrate ; Mr. A. B. Chatterjee, Chairman and Mr. W. Simpson, Director of Production, Tea Board ; Mr. H. Loss of Norst Hydro Elektrisk, Oslo and Mr. S. Gylseth of Norinco Ltd. ; Mr. T. R. Vohra, Deputy Chairman, Tea Board, with Mr. N. T. Rosinishvili, Mr. N. V. Lachritsk, Mr. K. I. Djalagania, Mr. A. V. Khourodze and Mr. V. Koutchouk from the U.S.S.R. Tea Industry ; Mr. J. Flemal of the Institute National Pour Etudes Agronomique au Congo ; Dr. B. V. Keskar, Minister of Information and Broadcasting, Government of India ; Mr. Mahrotra, Judge of the Assam High Court.

TOURING

The Director visited gardens in the Terai and Dooars in January, Cachar in February, and Darjeeling and Dooars in March. He visited the North Bank Advisory Branch in January and September and again visited the Dooars in November as a member of the Tea Board Sub-Committee. The Director visited Calcutta and other centres in connection with meetings listed below.

MEETINGS

The Director attended the following Indian Tea Association Meetings : The Terai Planters' Association, Annual General Meeting on 22nd January; the Dooars Branch Indian Tea Association Annual General Meeting on 23rd January; the Surma Valley Branch Indian Tea Association Annual General Meeting on 5th February; Assam Branch Indian Tea Association General Committee Meeting on 12th February; Annual General Meeting of the Indian Tea Association, Calcutta on 7th March; A meeting of the General Committee of the Dooars Branch Indian Tea Association on 11th March; The Darjeeling Branch Indian Tea Association Annual General Meeting on 15th March ;The Assam Branch Indian Tea Association Annual

General Meeting on 15th November; Quarterly meetings of the Scientific Department Sub-Committee on 6th March, 5th June, 18th September, 11th November and 18th December, and a special meeting of the Scientific Department Sub-Committee on 10th April. Zone and Circle meetings were attended locally throughout the year.

The following Tea Board Meetings were attended by the Director: Scientific Liaison Committee meetings on 24th and 25th January and on 20th March (in the Dooars), Tea Research Liaison Committee Meetings on 25th April, 22nd September and 19th December.

The Director attended or was represented at the following meetings of the Indian Council of Agricultural Research: 12th Meetings of the Crop and Soils Wing (represented by Dr. D. N. Barua) 6th June till 11th June; Advisory Board Meeting on 17th, 18th and 19th November (attended by Director) and Special General Meeting on 31st December (represented by Mr. Hadfield).

The Director either attended or was represented at the following non-Indian Tea Association Meetings: A Meeting of the Governing Body of the Assam Agricultural college on 24th March. The Annual Scientific Conference of the United Planters' Association of South India (represented by Mr. Green), Indian Tea Planters' Association Annual General Meeting on 12th April (represented by Mr. Grice), Assam Agricultural College Selection Committee on 2nd and 12th August; Jorhat Industrial Training Institute Selection Committee on 21st and 22nd September; A meeting on Food Production convened by the Assam Government on 29th September.

CONFERENCE

The 15th Annual Conference was held at Tocklai on the 11th, 12th and 13th November. The theme of the 1958 Conference was "Engineering Development and Manufacture." On the first day papers were read on various aspects of this theme, by Mr. McTear, Dr. Barua, Mr. Glover and

Mr. Gokhale. Mr. Gokhale, having recently returned from Russia dealt with mechanisation in that country. Further papers were read on the second day by Mr. McTear, Dr. Bhatia, Mr. Trinick and Dr. Roberts. On the third day one paper was delivered by Mr. Heath and the rest of the session devoted to delegate's questions. Throughout the Conference papers were followed by general discussions of the subjects concerned. Afternoon demonstrations were arranged on the first two days. These demonstrations included the latest developments made by the Engineering Department at Tocklai, improved spraying machinery, the mechanical harvester and pruning machine at Borbhetta and visits to two estates, where, at one, a continuous withering machine and, at the other, the McTear Rotorvane were undergoing commercial operation. A tour of the Tocklai laboratories was also arranged. Minutes of the full proceedings were distributed to all who attended the Conference and were circulated to all committee members.

In addition to Tocklai Staff the following attended the Conference :

Delegates.—N. S. Coldwell, Esq., Chairman, Indian Tea Association, Scientific Department Sub-Committee Calcutta ; R. C. Reynolds, Esq., A.B.I.T.A. Zone I South Bank; R. W. Gawthropp, Esq., A.B.I.T.A. Zone II South Bank; G. Hyatt, Esq., A.B.I.T.A. Zone III North Bank; G. A. Verinder, Esq., Dooars Branch Indian Tea Association; J. F. Hall, Esq., Dooars Branch Indian Tea Association; E. J. Dewey, Darjeeling Branch Indian Tea Association; A. M. Shaw, Esq., Surma Valley Branch Indian Tea Association.

Scientific Department Sub-Committee.—H. K. Fitzgerald, Esq., Balmer Lawrie and Co., Ltd.; D. L. Betts, Esq., Gillanders Arbuthnot & Co., Ltd.; A. C. H. Dolphin, Esq., Shaw Wallace & Co., Ltd. ; A. K. J. Henderson, Esq., James Warren & Co., Ltd.; P. B. Nicholls, Esq., Williamson Magor & Co., Ltd. ; E. A. H. Adams, Esq., Planters Representative.

Calcutta I.T.A., and I.T.A. and B.C.C. Staff.—L. T. Carmichael, Esq., *Chairman*, I.T.A. ; J. E. Atkins, Esq., Additional Adviser ; W. F. Joyce, Esq., Assistant Secretary.

Representatives of Agency Houses.—C. R. F. Mackenzie, Esq., Davenport & Co. (P) Ltd. ; M. C. Whear, Esq., Duncan Brothers & Co., Ltd. ; J. M. Storrie, Esq., Gillanders Arbuthnot & Co., Ltd., K. Welsh Esq., James Finlay & Co., Ltd. ; D. J. Simpson, Esq., Jardine Henderson Ltd. ; E. Lumley Ellis, Esq., Kilburn & Co. (P) Ltd. ; J. E. M. Turpin, Esq., Macneil & Barry Ltd. ; J. C. Crawford, Esq., Octavius Steel & Co., Ltd. ; J. A. Morice, Esq., Williamson Magor & Co., Ltd. ; T. H. Edye, Esq., Balmer Lawrie & Co., Ltd.

Tea Board.—A. B. Chatterjee, Esq., Chairman; W. Simpson, Esq., Director of Production.

United Planters' Association of Southern India.—W. J. J. Bullick, Esq.

Ross Institute.—Dr. A. Gilroy, Principal.

Assam Agricultural College.—Dr. M. C. Das, Principal.

Individual Guests.—B. H. N. McNeill, Esq., Scientific Officer, Jokai Assam Tea Co., Ltd. ; N. Borbora, Esq., Scientific Officer, Jorehaut Tea Co., Ltd. ; S. G. B. Brown Esq., Deputy Superintendent, Jorehaut Tea Co., Ltd. ; J. C. de la Mare, Esq., Superintendent Chulsa Tea Co., Ltd. : J. C. Day, Esq., Superintendent, Buxa Duars Tea Co., Ltd. ; E. H. Adamson, Esq., Nagri Farm Tea Co., Ltd. ; J. P. Hannay, Esq., Julia Tea Estate ; A. B. Anderson, Esq., West Jalinga Tea Estate.

COURSES

Three General Lecture Courses were held between 17th February and 7th March, the duration of each being increased in 1958 to 5 days. About 25 planters attended each course.

The courses were again run mainly by the Assam Advisory Branch and covered all main aspects of tea culture and manufacture. Two three-day Vegetative Propagation Courses run by the Agricultural Branch were also held between 20th and 26th November. Eight apprentices received training during 1958.

PUBLICATION

The following Tea Encyclopaedia Serials, Journals and Articles in addition to the usual Quarterly Reports were issued by the Scientific Department during the year.

Tea Encyclopaedia Serials :

119 Control of Diseases of Green Crops.

120 Paddy Cultivation.

121 Handling of Plant Protection Products and Hazard to Operators.

122 Classified Index of Encyclopaedia of Tea.

123 General Index of Tea Encyclopaedia.

124 Vegetative Propagation—Clonal samples sent to Tocklai for tasting.

125 Selective Nurseries.

126 Clonal Selection Schemes—Basic Programme for Selection and Propagation.

127 Clonal Selection Schemes—Clonal Trials and Records.

128 Clonal Selection Schemes—Nucleus Clones.

129 Clonal Selection Schemes—Field Selection Methods.

In addition to the above 13 serials were revised and re-issued during the year.

Periodicals :—

Annual Report of the Scientific Department for 1957.

Two and A Bud (Tocklai News Letter) Vol. V, No. 1, 2, 3 and 4.

Cachar Quarterly III, Nos. 1, 2, 3, & 4

Articles and Scientific Papers :

1. Life Expectation of Indian Tea Plantations by W. Wight—*The Commercial Times*—January, 1958.

2. Enzymic Oxidation of Polyphenols to Banzotropolones by E. A. H. Roberts—*Chemistry and Industry*—No. 4, January, 1958.

3. Tetanus by Dr. S. K. Sen—*Indian Medical Journal*—February, 1958.

4. Rate of Calcium Loss Resulting from Ammonium Sulphate Treatment of Tea Soil by N. G. Gokhale—*Nature*—Vol. 181, No. 4606, February 8th, 1958.

5. Murexide Test in Paper Chromatography by N. B. Chanda and S. Chakravarty—*Nature*—Vol. 181, No. 4612, March 22, 1958.

6. Pretreatment of Tea Cuttings for Distribution by Mail by W. Wight—*Camellian*—Vol. 9, No. 2, March '58, (Reprinted).

7. The Agrotype Concept in Tea Taxonomy by Dr. W Wight—*Nature,* Vol. 181, No. 4613, March 29, 1958.

8. The Chemistry of Tea Manufacture in North East India by E.A.H. Roberts—*Journal of the Science of Food and Agriculture*, 9th July, 1958.

9. *Septobasidium theae* Beedijn and Steinmann from Assam by K. C. Sarmah and V. Agnihothrudu—*Science and Culture* Vol. 23, No. 13, April, 1958.

10. The Phenolic Substances of Manufactured Tea II—Their origin as Enzymic oxidation products in Fermentation by E.A.H. Roberts—*Journal of the Science of Food and Agriculture* Vol. 9, April, 1958.

11. The Scope of Mechanization in Tea Production in North East India by P. M. Glover—*Tea and Rubber Mail*—Vol. 81, No. 4816, May 22nd, 1958.

12. Agrotype Concept in Chemical Analysis of Tea by Dr. W. Wight—*Nature*—Vol. 181, No. 4619, May 10th, 1958.

13. A Statistical Proof of the Seasonal Variation of Soil pH by N. G. Gokhale and A. K. Sen Gupta—*Journal of Indian Society of Soil Science*—Vol. 6, No. 12, June, 1958.

14. Paper Chromatography as an aid to the Taxonomy of Thea Camellias by E.A.H. Roberts, W. Wight and D. J. Wood—*New Phytologist*—Vol. 57, No. 2, July, 1958.

15. Notes on Fungi from North East India, I. A. New Genus of Tuberculariaceae by V. Agnihothrudu—*Mycologia*, Vol. 50, No. 4, July-August, 1958.

16. The Phenolic Substances of Manufactured Tea III—Ultra violet and Visible Absorption Spectra by E. A. H. Roberts and Miss D. M. Williams—*Journal of the Science of Food and Agriculture*, No. 4, 1958.

17. Effect of Termite Activity on the Chemical Properties of Tea Soils by N. G. Gokhale, S. N. Sharma, N. G. Bhattacharyya and J. S. Dutta—*Science and Culture*, Vol. 24, No. 5, November, 1958.

18. Effect of Prolonged Ammonium Sulphate Treatment on the Calcium Status of A Tea Soil by N. G. Gokhale and N. G. Bhattacharyya—*Empire Journal of Experimental Agriculture*, Vol. 26, No. 104, October, 1958.

19. Species Hybrids of Tea by D. J. Wood and P. K. Barua—*Nature*, Vol. 181, No. 4624, June, 14, 1958.

LABOUR RELATIONS

The dispute with the Tocklai Employees' Union regarding terms of service, mentioned in last years report and initiated by the union early in 1955, was referred to tribunal which was

set up to adjudicate on the dispute. Hearings were completed in December, but preliminary work in connection with the tribunal took up much time throughout the year. The award of the tribunal was not announced by the end of the year. An ancillary dispute regarding the discharge of an employee was heard by the same tribunal.

A dispute raised by the Jorhat Chah Mazdoor Union concerning the discharge of an employee (since deceased) was also referred to tribunal, but was subsequently referred to the High Court, the decision of which is still awaited.

A protracted dispute instigated by the Jorhat Jilla Chah Mazdoor Sangha regarding the status of certain employees continued throughout the year. Efforts made by the Association to investigate the matter and come to an amicable settlement failed. Further reference to official adjudication is expected.

In general, domestic and day-to-day relationships between staff, employees and labourers were satisfactory throughout the year.

LIBRARY

180 Books were added to the library during the year bringing the total at the end of December to 1373. Subscriptions were continued throughout the year to 91 journals and periodicals from various countries, and 71 other periodicals are regularly received on an exchange basis. Considering all issues of each journal a total of 1234 periodicals were received. In addition 944 pamphlets, 2 maps and a considerable quantity of advertising literature were received.

Staff and visitors used the reference and lending sections extensively, about 800 publications being requested for reference and 1,500 being issued on loan.

Branch libraries were maintained and supplied during the year.

GUEST HOUSE

The Guest House supervisor was on leave during 1958 and her duties were temporarily taken over by Mrs. Blair.

437 individual overnight guests used the Guest House, but many (*e.g.* those attending courses and visitors to the Jorhat Exhibition) stayed several nights. 367 casual guests used the Guest House, which is a marked increase over previous years. Two rooms were permanently booked for Tocklai staff, which considerably strained the accommodation resources at peak periods.

GENERAL REMARKS

There has been an increase in the establishment at Tocklai since 1955 mainly for the purpose of implementing the recommendations of the 1953/54 Engledow Commission of Enquiry on the Scientific Department. In the case of officers and additional officers the increase is constituted as follows :—

One Statistician (senior officer grade) to organise surveys and to participate in extended experimental work, particularly outstation experiments (as recommended by the commission).

One Research Engineer (now officer grade) to assist Senior Research Engineer with his duties.

One Assistant Agriculturist (additional officer grade) to allow for expansion of field experiments in tea gardens, and for the taking over of the responsibility for these by the Agricultural Branch from the Advisory Branches (as recommended by the commission).

One Pesticide Testing Officer (additional officer grade) to take the ever increasing work of testing pesticides off the entomologist and mycologist.

One Additional Officer in the Botanical Branch to free one of the botanists (now the Selection Officer) for the advisory duties on tea propagation.

Two Advisory Officers to allow for the extension of advisory services recommended by the commission.

Two Assistant Advisory Officers (additional officer grade one appointed in 1955) to allow for the extension of the advisory services to non-members.

During the period the post of Executive Officer, which had lapsed was revived and filled by internal transfer, and a post for an Assistant Physical Chemist has remained unfilled during the period.

This represents a 27% increase in the officer and additional officer grades. The corresponding increase in the junior staff grades is 31% of the 1955 establishment.

With an expansion in the establishment of approximately 30%, an expansion of the same order might be expected in the work of the station. It is not possible to gauge accurately the output of work of the station, but, as will be seen from the comparisons given later in this report, the expansion of items of work for which statistics are available indicates a far larger increase. For example: advisory visits in 1958 were 117% more than in 1956; advisory letters (from advisory branches) were 78% more in 1958 than in 1957 (no record for 1956 available); averaging several different types of samples indentified or tested by scientific branches at Tocklai there has been an increase of 91% in 1958 over 1956. In this last case it should be noted that additional scientific branch staff were appointed to carry out increased research, and *not* increased ancillary advisory work. In the tea tasting branch, without any increase in staff (other than a typist) the increases in tasting in 1958 over 1956 and 1957 were 95% and 22% respectively for all samples, and 165% and 50% respectively for advisory samples.

This exceptional increase in the station's activities is further reflected in the amount of correspondence which has passed through the Director's Office. The number of letters received in 1958 was 66% greater than in 1956 and 58% greater than in 1957 and letters despatched were 57% and 14% greater for the same years. It should be noted that despatches have been reduced by improved organisation.

These figures all stress the much increased interest in, and use of, Tocklai and its services which is noted below, and which is distinct from the normal increase in the station's research activities resulting from the 30% expansion indicated above. That this increased interest has arisen mainly from the producers

for whom the station caters is demonstrated by the disproportionate increase in the work of the advisory services viz. 117% increase for a 60% increase in staff.

MEDICAL

In 1958 an increased number of patients required treatment, the total number of cases being 21,003. Of these 153 cases were admitted to hospital for surgical and medical treatment, X'ray examination, and laboratory investigation.

Conditions which required frequent treatment were: Influenza and Bronchitis, which persisted throughout the year amongst patients of all ages; other respiratory diseases were Asthma, Pneumonia, Broncho-pneumonia ; one case of suspected Tuberculosis of Lungs and 4 positive cases of Pulmonary Tuberculosis; various cases of Gastro-intestinal disorders including Amoebic and Bacillary Dysentery, Hookworm and Round worm infection, Colitis, Enteritis and Gastritis; different Eye, Ear, Nose and Throat Diseases including Opthalmia, Blephritis, Otorrhoea, Rhinitis, Epistaxis, Pharyngitis and Tonsillitis; skin diseases including Scabies, Impetigo, Pemphigus, Dermatitis and Eczema.

Other conditions which required occasional treatment were: Anaemia, Food poisoning, Stomatitis, Gastric ulcer, Duodenal ulcer, Nephritis, Rheumatism, Herpes, Goitre, Neuralgia, Night blindness, Corneal ulcer, Allergic and Hypertensive disorders; accidental wounds of different degrees and Burns. Tetanus was avoided in all wound cases but 47 patients required prophylactic Anti-tetanic injection. Two cases of Typhoid occurred but there was no incidence of Cholera or Small Pox. Other infectious diseases were Mumps, Measles, Chicken Pox, Whooping Cough and Diptheria. Nine cases required antirabic injections following dog bite.

Antimalaria work at Tocklai and Borbhetta continued throughout 1958. The larval survey continued and re-production of *Anopheles minimus* was controlled throughout the rains. Efforts were also made to keep the general mosquito population under control by regular spraying with Malariol. Eight

species of Anopheline larvae including *Anopheles minimus* were collected and identified.

As in 1957 flies were a major problem during the hot season and there appears to be no effective control measure available.

BUILDING AND MAINTENANCE

Construction.— As in previous years major construction work was mainly entrusted to contractors. Work completed by contract during 1958 included : reconstruction of bungalow No. 11 in replacement of the original bungalow destroyed by fire ; extension of the Biochemical and Botany Laboratories; a new bungalow, No. 15 ; extension to Bungalows No. 6, 12 and 14; extension of the Tea Testing Laboratory ; construction of 13 servants quarters. Work completed by the Maintenance Department during the year included : replacement of 1,200 gallon water tank; fencing experimental areas, servants colony and new bungalow compound; replacement of part of gas main and water main; relaying general office floor. Work in progress at the end of the year included: extension of Entomology laboratory (contract) ; Extension of dispensary (contract) Construction of Labourers Rest Room (contract) Surfacing of main road (contract).

Maintenance.— Routine repairs and maintenance continued throughout the year in particular five roofs were repainted and internal decoration of 6 bungalows was carried out.

Stores.— Steel and cement and A.C. Sheets were received in sufficient supply for the first time for several years.

Transport.— A new 4 ton Fergo Truck was delivered in March, which has eased the transport situation slightly. The Botany Branch took delivery of a Jeep and trailer and the Testing Unit acquired a Hindustan Traveller.

Station transport strength at 31.12.58 was :

1 Studebaker Saloon (Director's Car)
1, 4 Ton Truck

1, $1\frac{1}{2}$ Ton Truck

2 15 cwt. Pick-ups (one on permanent detachment to Agriculture Branch and the other normally allotted to the Resident Medical Officer).

1 Land Rover.

1 Jeep and Trailer (on permanent detachment to Botany Branch).

1 Hindustan Traveller (on permanent detachment to Testing Unit).

Of the above the Land Rover and $1\frac{1}{2}$ Ton Truck require constant and major maintenance to keep them running.

RESEARCH AND EXPERIMENT

Detailed reports of the research and experiment carried out by each branch and section of Tocklai form the main part of this Annual Report, and only brief summaries of the more important aspects of these are given here. It is of course not possible to detail all the station's work in the branch reports, and individual research workers publish their results from time to time in the scientific press. However, certain detailed studies have been included as appendices to some branch reports in order that the workers concerned can put on record unfinished work, or interpretations and conclusions of a provisional or interim nature, some of which may be controversial.

No change in the station's research policy took place in 1958, and programmes of work continued with only minor alterations. The Statistical Branch and the Pesticide Testing Unit of the Plant Pathology Branch both started functioning during the year, and, as will be seen from the reports concerned, are already making their contribution to the station's investigations. The Agricultural Branch has now completed taking over the responsibility for the conducting of long term out-station experiments, though, of necessity, local supervision remains with the advisory officer on the spot.

During 1958, several research officers were given opportunities to make tours outside north east India, and to visit

research and other organisations elsewhere. These tours and visits were mainly of value to the officers themselves in the conduct of their research, but Mr. Gokhale's visit to the U.S.S.R. as a member of a Government delegation and Mr. Green's visit to Ceylon to attend a Symposium on Vegetative Propagation are of wider interests. The former has been reported on independently, and Mr. Green has incorporated a record of his visit into an article which is given in an Appendix to the Botanical Branch Report.

Mention is made below of the increased amount of support which the advisory services are getting from scientific branches at Tocklai, and attention is drawn to the possible adverse effects which this may have on their research work.

Physico-Chemistry & Climatology :

Investigations on soil nitrogen have been continued in the long term experiments at Borbhetta in order to study seasonal changes and long term trends in nitrogen content. In studying the relationship between the tea bush and soil pH it has been shown, as would be expected, that an increase in available aluminium is associated with a fall in pH. Further work on the recovery of phosphate by green crop confirmed efficient recovery from superphosphate, but indicated practically no recovery from rock phosphate. Foliar analysis of tea was continued and data is being accumulated, which will in due course be published independently. Analysis of leaves from the Ammonium Chloride/Ammonium Sulphate experiment showed a marked uptake and gradual accumulation of chlorine in the plant.

This branch continues to be responsible for the meteorological observations made by the Scientific Department, and certain climatological studies have been conducted on the available data. These are presented in the report, and stress, amongst other things, the relative distribution of rainfall in the different tea areas.

Botany :

The Research of the Botanical Branch on the morphology, physiology, systematics and breeding of the tea plant, and the

definition of tea populations has continued. Aspects of this work have been presented in scientific papers published, or under preparation, in 1958. Attention is drawn to papers on the place of morphological and chemical characters in the taxonomy of tea, and on the agrotype concept and its relation to the definition of tea populations.

A review of the nutritional relationship between tea and tea populations, and shade and fertilizer is appended to the branch report. This raises many important issues, some of which must remain controversial till further experimentation has been conducted and more data made available. It is, however, an important and essential contribution to the further understanding of the mechanism of shade, and the issues which it raises themselves justify the presentation of the data.

Work on breeding and selection has continued. On the practical side eight new vegetative clones have been multiplied for release to members, three new seed baries for the production of biclonal seed for progeny testing have been established and, one biclonal seed (Stock 367) has been put into trials in Assam, Cachar and the Dooars. The experience of the Botanical branch in the selection of clones and seed bearers has been put at the disposal of members of the Association by the initiation by the branch of an advisory service for this purpose. This is mentioned below.

Agriculture :

Forty six field experiments run by the Agricultural Branch were in progress at Borbhetta during 1958. This branch has now taken over responsibility for all the Scientific Department's long term agronomic field experiments in the tea gardens of north east India. These totalled fifty seven in 1958. There has been a steady expansion in these out-station experiments during the last few years, as can be seen from the substantial number now in progress. These experiments are repeats, or modifications, of experiments which have given positive results at Borbhetta, and are designed to test the validity of the Borbhetta results, or locally suitable modifications of them, under the range of soil and climate conditions for which the Scientific Department caters.

It is not possible to submit reports on all the experiments being carried out at Borbhetta, but selected experiments have been reported on in detail. These include short term experiments completed in 1958 and long term experiments which have reached a critical stage or are showing interesting results. In particular long term pruning and plucking experiments have been reviewed this year. The results reported largely confirm methods already recommended. Important comparisons between ammonium sulphate and other nitrogenous fertilizers, in particular ammonium chloride and urea, are continuing. Short term experimental results have cast further doubt on the value of urea as a nitrogenous manure, and have stressed the value of phosphate as a fertilizer for young tea and for green crops.

Out-station experiments, as distinct from those at Borbhetta, are reported in appendices to the reports of the advisory officers concerned. Generally speaking these experiments confirm the importance of N as a nutrient in most soils and regions except in Bheel soils in Cachar where benefit from P and K is confirmed. There is, however, a definite limit to the economic level of N application.

Most pruning experiments (in Cachar, Dooars and Darjeeling) indicate that higher yields are obtainable by biennial or longer pruning cycles.

Plant Pathology—Entomology :

The establishment of the Pesticide Testing Unit has relieved this section of time consuming work on the screening of insecticides and acaricides, and has allowed of greater study of the life history and biology of tea pests, and their relation to environmental, cultural and varietal factors. These studies have been coupled with trials on chemical and other methods of control being related to the biological findings.

Priority has been given to the study of red spider. Some of the results of these studies are submitted in the Entomological Section report, and the more detailed investigations have been prepared for publication (part in the press and part under preparation). The observations reported by the senior entomo-

logist confirm the importance of the practice of defoliation in controlling red spider mite, and indicate other practical possibilities. However, further work on the physiological effects of defoliation on healthy and weak bushes still needs to be done before firm recommendations can be made. Co-operation, specially in experiments on chemical control, has been given by scientists of interested firms specially Messrs. Tata Fison and Messrs. Philips Roxane.

Purple mite, looper caterpillar, and flush worm are three other pests of at least local importance, which were studied in 1958. In the case of the latter a special investigation was necessary to investigate alledged increase of flushworm following dieldrin application to the soil to control termites. No significant effect of dieldrin could be found, but observation made by Senior Advisory Officer, Cachar, and given in his report leave this matter still in doubt. Limited observations and control trials were made on certain less important pests of tea and on tea seed bug.

Work on eelworm has continued, but has been handicapped by the continued inability to find an assistant experienced in nematology. However the branch has been assisted in this work by an expert from Messrs. Tata Fison, who was offered facilities at Tocklai to carry out investigations on the identification and assessment of eelworm, as well as on methods of control.

Pests of shade trees, which are sometimes responsible for serious damage, were given some attention.

The Entomological Section co-operated with the Mycological Section and the Statistician in a Survey of Pests and Diseases which was initiated in 1958. A start has been made in Assam, and, following the experience gained there it will be extended to other tea growing regions.

Plant Pathology—Mycology :

As in the case of the Entomological Section, this section has been able in 1958 to carry out more biological research on

tea diseases, and has had more opportunity to coordinate this with chemical control trials, rather than carry out purely empirical trials of fungicides. In this connection, the work carried out in 1957 in co-operation with Messrs. Plant Protection Ltd. has been followed up.

Studies on the control of root diseases by formulations of pentachloronitrobenzene were continued, but the detailed investigations and observations which have been carried out have indicated that these formulations have no practical effect in controlling root diseases of tea.

In view of the importance of root diseases, studies on the rhizosphere and on the soil microflora have been continued. While studying the fungicidal value of pentachloronitrobenzene the effect of this product on the soil microflora was studied and the results of the investigation are given in an appendix to the section report.

The completion of the trials with "Fernide" (tetra-methyl-thiuram-disulphide) have confirmed the results anticipated last year, and show that this product has not increased tea seed production. Further studies on the *Botrytis* associated with tea flowers and its relationship with the tea flower indicate that it is probably not an agent which affects pollination or set or retention of seed. "Fernide" in low concentrations is toxic to this *Botrytis*. Details of these investigations are given in an appendix to the section report.

As mentioned above the Mycological Section participated in the survey of pests and diseases started in 1958.

As in previous years the Mycological Section was called on to identify many specimens of tea diseases and to advise on their control. The section report contains an analysis of the specimens received by disease and district. It will be noted that these have come mostly from the Assam valley; not because the incidence of diseases is heavier there, but because much identification is done elsewhere by advisory officers without reference to Tocklai.

Plant Pathology—Pesticide Testing Unit :

Dr. T. D. Mukerjea joined the Tocklai staff early in 1958 to take charge of this unit, and the unit became fully functional in the course of the year. The unit has been engaged on the standardisation of test techniques and the establishment of test insects and mites. Fortunately on account of import restrictions fewer requests than anticipated were received for testing of proprietary formulations, and there has been time to attend to this standardisation and other matters.

Commercial testing and certification were confined mainly to the renewal of certificates for products already approved, and the testing of already established products. A number of products have been tested for tainting and samples have been prepared for manufacturers interested in evaluating toxic residues for the establishment of tolerance limits. In this connection manufacturers have made little progress in getting residue tolerances for tea scheduled in the United States, apparently due to difficulties raised by the authorities there.

Screening trials for our own information, as distinct from commercial testing, have been carried out on new pesticides some in co-operation with the manufacturers mentioned above. Particular attention has been paid to acaricides for control of red spider, copper fungicides for black rot control, and nematocides. These trials are still in progress, but it will be seen from the report that some of the acaricides are already showing promising results.

Biochemistry :

Following Mr. D. J. Wood's retiral on 20th April, Dr. I. S. Bhatia took over the responsibility for the Biochemical Branch on August 16th, and the work of the branch has continued under his direction. The visit of Dr. Roberts was of great value to the branch in the arranging of programmes of work and in maintaining liaison with the London laboratory.

Several of the long term investigations continued, though in some cases with change of emphasis. Further work was done on the chemical differences between genetically different

types of tea, and differences in the sugars and anthocyanins between the Assam, China and southern forms of tea were demonstrated. Investigation of the volatile substances of tea continued, but was handicapped by difficulty in extracting these substances.

The important experiment in the chemical basis of quality was continued. In this experiment attempts are being made to correlate taster's assessment of quality with the content of certain the chemical constituents of tea. Results are detailed in the branch report.

The main new work started was a systematic investigation of the carbohydrates of tea. Preliminary investigations on simple sugars and pectins have been carried out, mainly with the object of establishing satisfactory methods of extraction purification and estimation.

As a contribution to the work being done on the polyphenols of tea, preliminary investigations on methods for estimating individual polyphenols have been carried out.

As in previous years the branch undertook manufacturing trials. This year an exploratory experiment was carried out on the effect of factory water on the colour of tea infusions. The results indicated that colour was affected by the following: iron in concentrations higher than found in most waters, highly alkaline water; lower concentrations of iron in the presence of high alkalinity; and permanently hard water containing Mg_2SO_4.

Tea Tasting:

9603 samples were tasted during 1958 compared with 7893 in 1957. These included samples from Tocklai field and manufacturing experiments and from the new machines, samples from estates (both member and non member) in connection with manufacturing problems, and samples submitted in connection with clonal selections.

Tea Taster co-operated with Research Engineer in the trials of the rotorvane and other new machines both in con-

nection with the manufacture and grading of the teas and their tasting.

There was an increased demand for the services of tea taster to visit factories and advise on manufacture. Because of pressure of work the tea taster was unable to meet all such requests and was unable to visit West Bengal during 1958. In all 41 factories were visited against 36 in 1957.

Engineering Development :

Further trial and development of the machines previously reported on continued in 1958. The commercial trial of the Rotorvane was carried a stage further by the manufacture and installation of a limited number of full scale commercial machines in members' factories. Most reports on these machines have been satisfactory. Generally speaking they have resulted in higher percentages of the better grades of tea and produced stronger and brisker liquors, though, in the case of orthodox teas, loss in appearance has been reported. The fact that the machine is a continuous one is a particular attraction in the case of C.T.C. and Legg Cut manufacture. Facilities for observation and trial were available in two commercial factories, and improvements resulting therefrom have been incorporated in the latest commercial Rotorvanes.

Mechanical harvesting trials during 1958 were mainly concerned with the effect of the machine on the tea bush. In the experimental treatments mechanical harvesting tended to produce more dormant shoots and reduced flushing during the second half of the season. Reference to these trials is made in the Agricultural Branch report as well as the Engineering report.

1958 saw the installation and preliminary trial of a continuous withering machine using hot air and gasses supplied directly from the heater. The preliminary trials gave satisfactory withering, and no tainting resulted from the direct heating.

The No. 2 continuous roller had been tried prior to 1958 and was known to give very satisfactory results with orthodox

methods of manufacture, and work on this machine in 1958 was concerned mainly with mechanical modifications designed to increase the amount of processing given by the machine, so that the time taken to complete the rolling could be reduced.

Preliminary trials with the new type of drier mentioned last year gave very satisfactory results, and further development of the machine is now taking place with the object of ultimately developing a combined fermenting and drying machine.

Statistics :

The Statistical Branch at Tocklai started to function in 1958 with the appointment of Dr. A. R. Sen as Statistician, though its full complement of assistants had still not been appointed at the end of the year, and it was therefore not working to full capacity.

The Statistician has been occupied mainly with the investigation and preliminery assessment of data already available at Tocklai, with advice on the planning and analysis of field experiments, and with the planning and organisation of sample surveys.

In a preliminary investigation on the relationship between climate and yield of tea certain significant correlations have been established. It is however too early to offer full interpretations of these correlations.

In connection with the planning of field experiments uniformity trials are being undertaken, and co-efficients of variation for different plot sizes and designs are given in the report.

The first of the surveys to be started is a survey of pests and diseases which is being carried out in co-operation with the Plant Pathology Branch. A two stage stratified sampling system has been designed for the survey, and data is being collected by means of questionnaires with the assistance of

survey assistants. Following the experience gained in the pilot survey in the Assam Valley it will be extended to other tea growing regions. Surveys of other agronomic factors will follow later.

ADVISORY SERVICES

In 1958 the expanded advisory services functioned fully, all officers being continuously resident in their own districts for most of the year.

Throughout the season specialist advice on selection of clones and seed bearers was made available by the initiation (at the end of 1957) of the post of Selection Officer under the Botanical Branch. The advice so provided is filling a long felt need. The selection officer's work in 1958 has undoubtedly cleared up many misunderstandings and mistakes on the part of planters and has at the same time provided the officer himself with useful experience of practical conditions and difficulties in garden propagation schemes.

The amount of advice sought in 1958 was larger than ever before, and, even with a full complement of officers in the field, all advisory staff were kept very busy throughout the season. Both I.T.A. (Calcutta) member gardens and non-member gardens increased their use of our services. The total number of garden visits made by advisory officers for all districts were 604 against 410 for 1957; and advisory letters written by advisory officers were 2,200 (approximately) against 1240 for 1957. These figures do not include visits made, or letters written, by the selection officer, or by scientific officers.

An analysis of visits by advisory staff in 1957 and 1958 is given in the following table.

It can be seen from the above that there has been an overall 50% increase in visiting in 1958 over 1957, and over 100% increase in visiting to non-members.

The increased use of Tocklai's advice was also reflected in the amount of work of an advisory nature which scientific officers were called upon to carry out. This is borne out by

in correspondence, and lectures. Demonstrations and courses (the last for all regions) were also organised.

This branch continued its co-operation in the "Fernide" experiment in tea flower disease and in eelworm control using soil sterilizer XX564/57, and results are reported in the branch report. Interest was also taken in weed control in thatch baries, on possible side effects of aldrin and dieldrin, and on the performance of different types of aerosol sprayers which became available for trial.

A report on the long term field experiments being carried out in the region covered by this branch is given as an appendix to the branch report. Not all experiments have been included this year.

Assam Advisory Branch—Assam (Brahmaputra) Valley : North Bank :

This section of the Assam Advisory Branch became fully effective in 1958. Advisory Officer and his staff were housed in temporary accommodation during the whole year, but progress on the completion of the permanent site has been satisfactory.

A total of 75 gardens were visited by the advisory staff of the branch in 1958. These visits were carried out mostly by the resident Advisory Officer, but special visits were made by Senior Advisory Officer, Assam and by Assistant Advisory Officer. Of the total two gardens were not members of I.T.A. Calcutta.

Certain insect pests both of tea and shade trees were particularly important during the season, and the question of side effects of aldrin and dieldrin dealt with in the Senior Advisory Officer's report (Assam Valley : South Bank) arose particularly in connection with these.

In addition to the long term agronomic experiments, which are the responsibility of the Agricultural Branch which are reported in an appendix to this report, Advisory Officer was given the responsibility for one of the proving trials of Stock 367, a new biclonal seed likely to be suitable for the drier conditions characteristic of this area.

Assam Advisory Branch—Cachar :

A total of 117 garden visits were made by the staff of the branch during 1958. Most of these were made by Senior Advisory Officer, Cachar, but 3 special visits were made by Senior Advisory Officer, Assam and 4 visits by Assistant Advisory Officer, Assam. 20 of the 117 were visits to gardens not members of the I.T.A. Calcutta.

Experiments in Cachar as elsewhere fall into two categories (1) the long term agronomic experiments, which are the responsibility of the Agricultural Branch and some of which are reported in the appendix to the advisory officer's report and (2) those conducted by the advisory officer, which are of immediate local practical interest. The latter include a manuring trial which has shown that there is a definite limit to the amount, and to the time, when nitrogenous fertilizers can be applied in Cachar, and a comparison of Tocklai and certain local methods of pruning young tea, which is indicating the superiority of the Tocklai method.

The Senior Advisory Officer, Cachar is also undertaking clonal selection to suit local conditions, and manufacturing trials to help to solve local problems.

West Bengal Advisory Branch—Dooars :

With the posting of an advisory officer to Darjeeling the West Bengal Advisory Branch report is again served in two parts one by Senior Advisory Officer for the Dooars and the other for Darjeeling and associated regions. The entire branch is administered by Senior Advisory Officer, West Bengal, who together with an assistant advisory officer undertakes routine visiting in the Dooars area. The duties of the assistant advisory officer are mainly concerned with non-member gardens.

During 1958 a total of 145 gardens were visited by advisory staff. This total included 34 non-member gardens. Most of the member gardens were visited by Senior Advisory Officer and most of the non-member gardens by Assistant Advisory Officer.

Attention has been drawn in the branch report to the very serious outbreak of *Helopeltis* in the Dooars in 1958, and also

to the persistent spread of the weed *Mikania.* Reference has also been made to an important shade tree experiment started in the Dooars. As in other regions, long term agronomic experiments are reported in an appendix to the branch report. Only two of these are being included this year.

West Bengal Advisory Branch—Darjeeling and Terai :

With the posting of an advisory officer (Mr. Grice) to Darjeeling in 1958 the Darjeeling and Terai advisory region was re-established as a separate unit within the West Bengal Advisory Branch. The unit caters for the Darjeeling area, the Terai and part of the Western Dooars.

During 1958, 128 visits were made to gardens in Darjeeling Terai and the Western Dooars. Of these 17 were to non members gardens. The Advisory Officer has been occupied mainly in getting to know his district, arranging accommodation, a meteorological station and so on.

As in other regions long term agronomic experiments have been reported in an appendix to the branch report. Most of these are included in this year's report.

BUTLER'S WHARF LABORATORY

A report of the research being carried out at the Association's laboratory at Butler's Wharf in London has been prepared by Dr. Roberts the Scientific Officer in charge, and is included in this Annual Report.

Further progress has taken place in the study of theaflavins and thearubigins in made tea in relation to certain commercial characteristics of tea. Figures are included in the report which show a relationship between theaflavin and thearubigin content; time of fermentation; and colour, strength, quality and briskness, all of which are known to deteriorate with over fermentation. Theaflavin and thearubigin content have also been shown to be related to the creaming down phenomenon in tea liquors.

Work continued at the laboratory on the identification, estimation, and structure of the chemical constituents of tea.

During November, 1958 Dr. Roberts paid a visit to Tocklai and, through the medium of the Tocklai Annual Conference, acquainted the Association with his work in London and practical developments which are likely to result from it. In this connection simplified methods of estimating the thearubigins and theaflavins were explained and demonstrated. Dr. Roberts' visit was also invaluable in maintaining the close liaison which now exists between the London and Tocklai chemical laboratories.

PHYSICO-CHEMICAL BRANCH

N. G. GOKHALE—Senior Physical Chemist

STAFF

The Senior Physical Chemist was on sick leave from 1st September to 13th October, after his return from Europe. Messrs. Gurung and Lama, meteorological assistants from the Advisory Branches, were trained as meteorological observers.

RESEARCH AND EXPERIMENT

Chemical Investigations :

Soil nitrogen status under continuous cropping and varying cultural practices in tea — This investigation continues and soil samples from a number of field trials, which are being carried out at Borbhetta as well as on commercial estates, are being examined. It is proposed to repeat this examination at periodical intervals in future, so as to collect information about the long term changes occurring under field conditions. The areas chosen consist of unshaded as well as tea under natural shade, certain experiments being carried out with tea shaded by bamboo screens, N.P.K. field trials, and also one experiment where cattle manure is being tried out against artificials.

Seasonal variation of soil nitrogen – Under the special conditions obtaining in tea (*i.e.* periodical addition of organic matter *via* pruning litter, shade tree droppings etc.) and also because of the seasonal changes in climatic conditions, the nitrogen status of tea soils may be expected to show a seasonal variation. An investigation has been started to study this, by making use of two long term field trials being carried out at Borbhetta. Preliminary results confirm a seasonal variation in the case of the top 9″ soil samples.

Availability of aluminium in tea soils — Some preliminary data in this connection were quoted in our annual report for 1955 (pages 15-16 refer). Further information is now presented in the form of a dot diagram (see figure 1) in respect of 94 soil samples collected from various tea districts of north east India,

the soil pH (of water extract) values varying between 4.0 and 6.5.

As may be expected, there is a general drop in the availability of aluminium with rise in soil pH, although there is, of course, a fair amount of variation in the values of available soil aluminium. It has, however, been explained previously that our working hypothesis is that it is the balance between the availabilities of certain cations in the soil which is important in the case of tea. Further work in this investigation is continuing.

Recovery of applied superphosphate by green crop—1957 field trial (Borbhetta area 103) – With reference to the discussion on page 24 of our annual report for 1957, an explanation is now necessary. It was stated previously that the pooled recovery figure for superphosphate treatment was 10% and 14% at the end of 3 and 7 months, respectively. The former figure is fully correct but the latter is an estimate of the *minimum* amount that must have been recovered: the actual amount recovered at the end of 7 months is likely to have been higher. The green crop was first lopped in July 1957 (*i.e.* at the end of 3 months) and it is estimated that approximately 6 out of the 10% phosphate recovered was thus re-applied to the soil in the form of loppings. The net recovery figure at the end of 7 months is therefore $10 + (14 - 4) = 20$, although it should be clear that this refers to 100 lb. of P_2O_5 applied originally as superphosphate and 6 lb. of P_2O_5 re-applied in July 1957 in the form of loppings. It is not possible to state with certainty that the phosphate recovered during the period July to November 1957 did not come from the loppings, but recent observations provide indirect evidence to that effect.

Recovery of applied superphosphate and indigenous rock prosphate by green crop grown in an acid tea soil (Borbhetta area 2 B)— Advantage was taken of a field trial being carried out at Borbhetta by the Agricultural Branch (for further details see that branch report) to obtain information about recovery of two phosphatic fertilisers and the results are presented here briefly.

Brief description of the field trial in Borbhetta area 2 B.—The manurial trial of the green crop consisted in application of superphosphate (P_2O_5 total 20%) and indigenous rock phosphate (P_2O_5 total 25%, citric soluble 12.4%) with and without sulphate of potash and there were also check (*i.e.* unmanured) plots. The statistical lay-out is randomised, there being four repeats (in four blocks) for each of the five treatments. Both the phosphatic fertilisers were applied to supply P_2O_5 at the rate 80 lb./acre, and sulphate of potash was applied to supply K_2O at the rates O and 40 lb./acre. The manures were applied in bands just before the green crop, *Crotalaria anagyroides* H.B.K., was sown by end of March 1958 in rows 2½ ft. apart. The plants were thinned out to 6″ spacing when they were 6″ high. The green crop was lopped twice during the year but in the case of the rows under study, the loppings were not returned to the soil. The green crop was uprooted and the area put under tea early in 1959.

To assess the phosphate recovery by the green crop, representative samples of whole plants were collected on the 19th July 1958 (just before first lopping) and the 26th November 1958, and loppings were collected on the 19th July, 1958 and the 24th September, 1958. The whole plants and loppings were sectioned and analysed as in the previous year. The phosphate recovery at the end of 4 months was calculated from the samples of whole plants collected in July, 1958. To obtain the total recovery at the end of 8 months, the amounts of phosphate contained in the loppings collected in July, 1958 and September, 1958 were added to those recovered in the whole plants collected on the 26th November, 1958 (remembering that in the case of the rows sampled, the loppings were not returned to the soil), and the results calculated from the totals so obtained.

Statistical analysis of the phosphate recovery data shows that the difference in the effects of superphosphate and rock phosphate treatment is highly significant and the performance of the latter was very poor. Mean values of the amounts of phosphate recovered in the case of the five treatments and the calculated percentage recoveries are given in table 1. The results in the case of superphosphate compare very favourably

with other published data and it is concluded that superphosphate is an efficient source of phosphate for green crops like *Crotalaria anagyroides* H.B.K. grown in our acid tea soils.

Table 1:—Recovery of applied superphosphate and rock phosphate by green crop—Borbhetta area 2 B

Fertiliser treatment	Total phosphate (P_2O_5) recovered in two periods			
	Upto July 1958 (in 4 months)		Upto November 1958 (in 8 months)	
	lb. per acre	% recovered	lb. per acre	% recovered
Check (unmanured)	7.4		20.7	
Rock phosphate (80 lb. P_2O_5)	7.5	0_{1}	21.1	0_{5}
Superphosphate (80 lb. P_2O_5)	14.5	8_{5}	41.6	26_{2}
Rock phosphate (80 lb. P_2O_5) + Sulphate of potash (40 lb. K_2O)	7.5	0_{2}	21.6	1_{1}
Superphosphate (80 lb. P_2O_5) + Sulphate of potash (40 lb. K_2O)	12.2	6_{0}	39.1	23_{1}
L.S.D. P=5%	4.6		4 0	
L.S.D. P=0.1%	9.1		8.0	

Analyses of the "dry weight" and "fresh weight" data show results to be similar to those for the phosphate recovery data. Data are also now available about the phosphate content of the green crop (separately for leaf, stem and roots) Phosphate content showed a marked increase with superphosphate application and there is also a pronounced variation with the age of the green crop. If and when some further field experimental data can be collected, it may be possible to work out methods to diagnose manurial requirements of green crops from both soil and foliar analysis.

Complete chemical analysis of clonal tea leaf— The object of this investigation was to obtain data about the inorganic cons-

tituents of tea leaf by making use of clonal material. There are previous data on the subject, but in all these cases the areas sampled consisted of commercial jats of tea. Full details of this investigation will be published elsewhere but brief results are presented here.

Four clones (namely 19/29/13, 20/23/1, 1/7/1 and 3/77) were selected for the experiment. Dr. W. Wight, Senior Botanist at Tocklai states that clone 19/29/13 is a complex hybrid showing some features of all the three taxa discussed by

Table 2

Table 2 : Chemical analysis of whole plucked shoots (two leaves and a bud)—averages for three dates of collection during 1956

	Clone number			
	19/29/13	20/23/1	1/7/1	3/77
Total ash % on dry wt.	6·1	6·1	6·7	5·7
Sulphur (SO_3) ,, ,, ,, ,,	0·73	0·77	0·74	0·68
Chlorine (Cl) ,, ,, ,, ,,	0·05	0·05	0·05	0·04
Sand + SiO_2 ,, ,, ,, ,,	0·07	0·07	0·08	0·08
Calcium (CaO) ,, ,, ,, ,,	0·71	0·78	0·76	0·58
Magnesium (MgO) ,, ,, ,, ,,	0·31	0·28	0·28	0·30
Phosphorus (P_2O_5) ,, ,, ,, ,,	1·07	1·11	1·13	1·09
Aluminium (Al_2O_3) ,, ,, ,, ,,	0·07	0.06	0·06	0.04
Potassium (K_2O) ,, ,, ,, ,,	2·58	2·60	3·03	2·57
Nitrogen ,, ,, ,, ,,	4·02	4·50	4·43	4·63
Manganese (Mn_2O_3) p. p. m. on dry wt.	555	460	468	486
Iron (Fe_2O_3) ,, ,, ,, ,,	87	96	94	95

Roberts *et al* [1] and probably also some features of *Camellia irrawadiensis*, whereas the remaining three are referable to *Camellia sinensis* var. *assamica* but none are typical and all three might be regarded as slightly hybrid.

Samples of leaf were collected on three occasions in 1956 (12th July, 9th August and 6th September, 1956) and the shoots were partitioned into bud, 1st leaf, 2nd leaf and stem for the purpose of chemical analysis. Official A.O.A.C. methods were used in all cases except for estimation of potassium and nitrogen for which slightly different methods were employed [2, 3]. There is a pronounced variation in chemical analysis for the different portions of plucked shoots, with the date of collection and finally in the case of the different clones. Results calculated on "whole plucked shoot" basis (*i.e.* two leaves and a bud) are presented in table 2.

Chlorine uptake by the tea plant with continuous application of Ammonium chloride (Borbhetta area B 28.1) — Previous data in this connection were quoted in our annual reports for 1956 and 1957 (pages 25-26 and 26, respectively, refer). The mean chlorine contents of the "2nd leaf" in the case of both ammonium chloride and ammonium sulphate treated plots during the three year period 1956-58 are presented in figure 2. In the case of the ammonium sulphate plots, the chlorine content has remained more or less steady, the value being always less than 0.050% on dry weight. When ammonium chloride is applied, the immediate effect is to raise the chlorine content but the value settles down to a more or less steady level by the end of the plucking season. There is, however, a gradual build up when application of ammonium chloride is continued year after year, and at the end of the 1958 season the value had reached 0.110% on dry weight, which is over double that in the case of the ammonium sulphate plots.

References:

[1]Roberts, E. A. H., Wight, W., and Wood, D. J.: (1958), The New Phytologist, 57, 211-225.

[2]For potassium, see Piper, C. S.: (1950), Soil and Plant Analysis, The University of Adelaide, 178-180.

[3]For estimation of nitrogen, a slightly modified A. O. A. C. microkjeldahl procedure was used.

During 1958, samples were also collected of "1st leaf over pruning cut" and "old leaf from below pruning level". Data about their chlorine contents are also now available and the values are much higher than those shown in figure 2. It appears that chlorine content is highest in the case of the "1st leaf over pruning cut" samples and the values with continuous ammonium chloride treatment are about five times higher than those for the ammonium sulphate plots.

There is evidence therefore that, under our conditions, continuous ammonium chloride treatment has resulted in accumulation of chlorine by the tea plant. What effect exactly the high chlorine content may have on liquor properties, especially if the build up continues with further application of ammonium chloride, is a matter for investigation. Data about the manufacturing trials carried out in 1958 from these plots and other details will be found in the report of the Agricultural Branch.

Foliar analysis of tea leaf — These investigations continue and further data have been collected during 1958 about the variation in chemical analysis with date and time (*i.e.* diurnal) of sampling, physiological age of leaf, kind of tea, manurial treatments etc. Results of our investigations will be presented in due course.

Climatological Investigations :

Percentage of dry and rainy days according to category of daily rainfall, in different tea districts of north east India — Figures of total yearly rainfall give no idea about the effectiveness of rain, and for this purpose, data are required about the structure and fine pattern of rain. A number of different analytical procedures are being employed in this study and data are now presented about the frequency distributions of rainy days by category of daily rainfall. Table 3 gives the data for thirteen tea estates from different sub-districts of north east India. Separate figures have been shown for the whole year, and for the four winter months November to February.

It is known that distribution of rainfall is favourable in Upper Assam whereas the position is quite different in the case

Table 3 : Percentage dry and rainy days according to category of daily rainfall, in different tea sub-districts of north east India

	Dry days and daily rainfall (in inches) exceeding	Assam valley												Darjeeling
		South Bank					North Bank				Cachar		Dooars	
		Doom Dooma	Sonari	Moran	Tocklai	Nowgong	Norh Lakhimpur	Bishnath	Tezpur	Mangaldai	Chutlabheel	Hailakandi	Toorsa Jainti	
total for the whole year	dry days	50.8	55.5	58.6	53.5	64 1	55.5	62.5	63.1	67.3	56.7	58.3	58.3	53.6
	0.01	49.2	44.5	41.4	46.5	35 9	44.5	37.5	36.9	32.7	43.3	41 .7	41.7	46 4
	.10	36.5	35.2	35.4	32.3	29.6	37.2	33.0	30.8	28 9	38.0	35.8	33.8	37.4
	.40	20.6	20.7	21.1	17.2	17.0	24.1	20.1	18.2	16.6	24.4	22 3	22.9	22.8
	.80	11.3	11 4	11.9	9.3	9.1	15.6	11.8	10.4	9.9	14.6	13.4	15.6	13 9
	1.20	6.6	6.7	6.7	5.0	5.0	10.5	7.5	6.7	6 1	9.3	8.5	11.4	9 2
during the period November to February	dry days	77.9	84.1	85.8	83.9	91.9	84.1	90 2	90.0	91.8	92.	92.	...	89.9
	0.01	22.1	15.9	14.2	16.1	8.1	15.9	9.8	10.0	8.2	7.2	7.5	7.8	10.1
	.10	12.6	9.8	10 3	8.3	5.1	10.8	7.5	6.5	6.2	5.2	5.6	4 0	5.7
	.40	3.9	3.2	3.5	2.2	1.7	4.2	2.7	2.2	1.7	2.6	2.8	1.4	1.6
	.80	0.9	0.8	1.0	0.7	0.4	1.6	0.9	0 7	0.4	1.4	1.4	0.5	0.6
	1.20	0.2	0.1	0.2	0.2	0.1	0.5	0.4	0.3	0.0	0.8	0.9	0.3	0.2
Data available for years		30	41	64	36	30	30	45	26	32	40	49	41	36

of tea estates in Lower Assam, especially in Nowgong, Mangaldai etc.: this is brought out clearly when the figures for Doom Dooma are compared with the other sub-districts. It may be seen that rain occurs in Upper Assam on approximately 49% of the days in the whole year, whereas as one travels down the valley the figure decreases and the corresponding figure for Lower Assam is only about 32-36%. The distribution of rainfall in the case of the Cachar, Dooars and Darjeeling estates quoted in table 3 is not much better than the 'drought prone' sub-districts of the Assam Valley.

The position is even more pronounced when data for the period November—February are examined. Rain occurs in Upper Assam on about 22% of the days during these four months, whereas the corresponding figure for the unfavourably situated tea sub-districts is below 10%.

Detailed rainfall data have been collected from a number of tea estates in north-east India and further information in this connection, including a statistical analysis of the wet and dry spells, will be presented in due course.

Analysis of Tocklai recording raingauge data — Some information in this connection was quoted in our annual report for 1954 (pages 71-75 refer). Data are now available for the six year period April, 1953 to March, 1959 and are presented here in brief.

(i) **Hourly distribution of rainfall** — The rainfall which occurred during successive four hour periods starting from 0800 hrs. Tea Time (which is Indian Standard Time plus 1 hour) are given in table 4 (for details see table 12). It should be mentioned that the local meantime at Tocklai is much nearer to the Tea Time mentioned above (the latter being only 13 minutes ahead) than to Indian Standard Time.

It will be seen that at Tocklai, over 50% of the rain falls between the hours midnight to 8 a.m., and about 70% between the hours 8 p.m. to 8 a.m.

Table 4 : Hourly distribution of rain (in inches) at Tocklai

	Rainfall during the hours (Tea Time)							Data not available (?)	Total rainfall
	0800-1200	1200-1600	1600-2000	2000-2400	2400-0400	0400-0800	total		
Total during the period April 1953 to March 1959 ...	58.53	33.55	43.76	75.29	126.57	111.62	449.32	39.64	488.96
% of total ...	13.0	7 5	9.7	16.8	28.2	24.8	100.0		

(Note : ? recording raingauge out of commission)

(ii) **Total duration of rain** — The actual duration of each rain shower was read off and the mean values are given in table 5 (for details see table 13).

Table 5 : Actual duration of rain at Tocklai.

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Total for the year
Mean value (in hrs.)	14.8	15.7	15.8	32.0	69.1	53.1	76.7	66 0	32.4	29.6	10.2	7.8	423.2
Mean duration of daily rainfall in minutes	29	33	31	64	134	106	149	128	65	57	20	15	

(iii) **Intensity of rainfall** — For reasons which have been explained previously, in soil moisture studies, it is important to know at what rate the rain falls. The absolute recorded maxima during the six year period are given in table 6.

Totals for the six year period according to certain arbitrary categories are presented in table 7 (for full details see table 14).

Table 6 : Absolute recorded maxima of rain intensity in various periods at Tocklai

	During a period of			
	3 min.	13 min.	33 min.	2 hours.
Rainfall in cents	21	85	188	312
Rain intensity in cents/hour	420	392	342	156
Occurred on	16th Oct. 1956	6th Oct. 1956	6th Sep. 1955	14th July 1954

Table 7 : Rainfall (in cents) by category of rain intensity (in cents/hour) at Tocklai

	Categories of rain intensity							Data not available	Total rainfall
	0—40	40—80	80—120	120—160	160—200	over 200	total		
Total during the period April 1953 to March 1959	17,431	8,412	6,699	5,107	2 543	5,082	45,274	3,622	48,896
% of total	38.5	18.6	14.8	11.3	5.6	11.2	100.0		

(Note : 1 cent = 0.01 inch of rain)

It is seen that at Tocklai about 38% of the total rainfall occurs at intensities less than 40 cents/hour and about 28% at rates higher than 120 cents/hour.

It should be mentioned here that the recording raingauge was not working for certain periods and therefore data in respect of about 8% of the rainfall which occurred during the six year period is not available.

PUBLICATIONS

Gokhale, N. G. : (1958) "Rate of calcium loss resulting from Ammonium Sulphate treatment of a tea soil", Nature, **181**, 4606, 426-427.

Gokhale, N. G. and Sen Gupta, A. K. : (1958) "A statistical proof of the seasonal variation of soil pH", Jour. Ind. Soc. Soil Sci., **6**, (No. 2), 103–104.

Gokhale, N. G. and Bhattacharyya N. G. : (1958) "Effect of prolonged sulphate of ammonia treatment on the calcium status of a tea soil", Emp. J. Exp. Agri., **26** (No. 104), 309–313.

Gokhale, N. G. Sarma, S. N., Bhattacharyya, N. G. and Dutta, J. S. : (1958) "Effect of termite activity on the chemical properties of tea soils", Science and Culture, **24** (No. 5), 229.

In the press : one paper in "Soil Science"

ADVISORY

Touring— The Senior Physical Chemist paid a visit to one garden in the Bishnauth circle. During the period June-July, the Senior Physical Chemist paid a visit to the U.S.S.R. and seven other East European countries as a member of a trade delegation sent out by the Government of India. A report about the tea areas of the U.S.S.R. is being issued separately.

Routine analytical work— A total of 1,405 soil and other samples were analysed during the year. The soil samples examined were in connection with selection of nursery sites, areas due for uprooting/replanting of tea etc.

Correspondence— During the year, 317 advisory reports were issued to tea gardens and, in addition, 625 other letters were written.

FIGURE 1
EXCHANGEABLE ALUMINIUM AND pH OF TEA SOILS

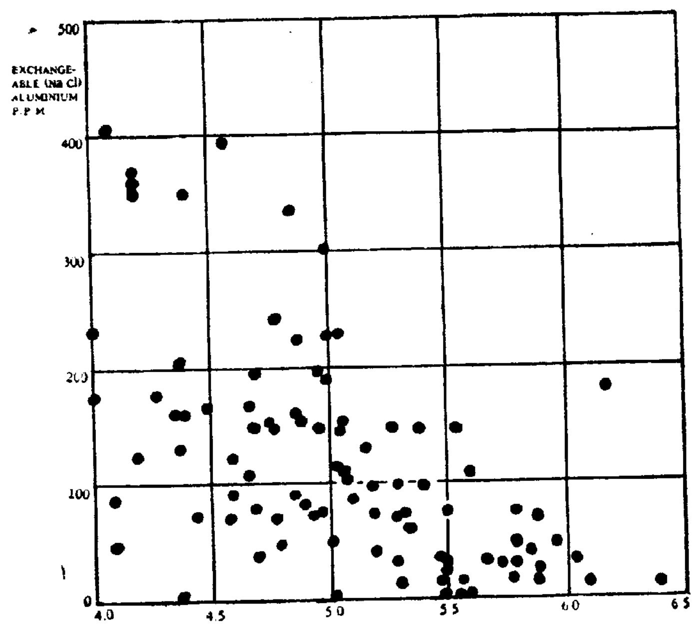
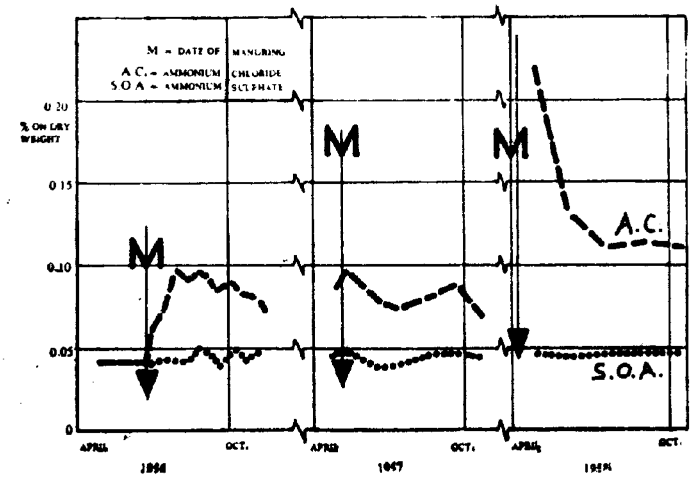


FIGURE 2
CHLORINE CONTENT OF SECOND LEAF WITH AMMONIUM CHLORIDE AND AMMONIUM SULPHATE TREATMENT



METEOROLOGICAL OBSERVATIONS

TOCKLAI STATION METEOROLOGICAL OBSERVATIONS, 1958

(TABLES 8 TO 11)

Table 8 :

Month	Mean temp. °F Max.	Mean temp. °F Min.	Sunshine in hrs	Rainfall in inches	No. of rainy days	Terrestrial min. temp. °F
January ...	73.8 (72.0)	51.7 (48.5)	5.6 (5.6)	0.39 (0.88)	5 (5)	47.2 (45.1)
February ...	72.7 (75.2)	54.9 (53.0)	5.4 (6.0)	1.43 (1.28)	11 (8)	50.8 (47.3)
March ...	86.2 (81.4)	60.1 (59.6)	7.7 (6.6)	0.07 (3.44)	3 (11)	54.8 (53.6)
April ...	86.3 (83.3)	67.8 (65.7)	5.9 (5.8)	4.03 (7.65)	20 (17)	65.2 (60.7)
May ...	82.8 (85.8)	70.8 (70.9)	3.9 (5.0)	15.84 (11.18)	25 (20)	69.9 (68.4)
June ...	91.9 (89.0)	77.6 (75.2)	5.9 (4.6)	8.67 (12.68)	18 (23)	76.3 (74.5)
July ...	91.2 (90.1)	76.9 (76.0)	5.9 (4.9)	25.32 (15.38)	30 (25)	76.5 (75.2)
August ...	87.9 (89.7)	76.3 (75.8)	3.6 (5.1)	15.35 (13.08)	29 (23)	75.6 (74.1)
September ...	90.8 (88.3)	76.5 (74.6)	6.3 (5.0)	5.40 (10.21)	15 (19)	75.4 (73.2)
October ...	86.0 (84.7)	72.8 (69.4)	5.2 (5.4)	6.64 (4.75)	15 (12)	71.6 (67.9)
November ...	83.0 (79.2)	60.9 (58.9)	7.2 (5.8)	0.03 (1.09)	1 (4)	57.9 (56.3)
December ...	74.7 (73.7)	55.3 (50.9)	4.9 (5.7)	0.77 (0.45)	4 (3)	51.9 (47.0)
Total ...				83.94 (82.07)	176 (170)	
Average ...	83.9 (82.7)	66.8 (64.9)	5.6 (5.5)			64.4 (61.9)

NOTE : – Data in brackets show previous averages.

Table 9 : % Relative Humidity, monthly averages

Hrs. I. S. T.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug	Sep.	Oct.	Nov.	Dec.
06 13	98 (97)	97 (96)	92 (93)	92 (92)	95 (94)	90 (92)	96 (94)	96 (95)	96 (95)	97 (97)	98 (98)	98 (98)
13 13	60 (61)	61 (57)	43 (59)	58 (66)	77 (72)	71 (75)	73 (75)	78 (76)	71 (75)	74 (74)	58 (66)	65 (64)

Table 10 : Vapour tension, monthly averages, in inches of mercury

Hrs. I. S. T.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.
06 13	0.399 (.390)	0.435 (.422)	0.512 (.520)	0.678 (.652)	0.760 (.786)	0.926 (.896)	0.944 (.920)	0.907 (.916)	0.920 (.907)	0.812 (.772)	0.545 (.554)	0.446 (.408)
13 13	0.464 (.451)	0.454 (.483)	0.492 (.573)	0.655 (.701)	0.806 (.812)	0.943 (.923)	0.967 (.952)	0.945 (.969)	0.956 (.948)	0.852 (.826)	0.610 (.637)	0.513 (.501)

NOTE :—Data in brackets show previous averages.

Table 11 : Soil temperature °F., % soil moisture and evaporation from U.S.A. open pan Evaporimeter and Piche Evaporimeter, monthly averages

Month	Soil temp. in BARE plot, at depth.						Soil temp. in GRASS plot, at depth						% soil moisture (top 9")		Evaporation in inches (daily mean)	
	at 0613 hrs. I.S.T.			at 1313 hrs. I.S.T.			at 0613 hrs. I.S.T.			at 1313 hrs I.S.T.						
	5 cms	15 cms	30 cms	5 cms	15 cms	30 cms	5 cms	15 cms	30 cms	5 cms	15 cms	30 cms.	morning	afternoon	USA open pan (1)	Piche (2)
January ...	55.1	61.8	66.0	74.9	68.0	66.1	62.8	65.2	67.3	69.8	66.9	67.5	13.0	12.7	0.051	0.065
February ...	59.8	63.2	66.8	75.5	69.1	66.7	63.7	65.8	67.7	71.6	68.1	67.8	13.2	13.1	0.080	0.078
March ...	67.6	71.7	75.2	88.9	79.6	75.0	69.7	72.6	74.4	81.8	75.9	74.5	10.1	9.7	0.139	0.166
April ...	73.0	75.8	78.7	89.7	82.7	78.6	75.3	77.7	79.1	85.3	80.7	79.2	12.4	12.2	0.194	0.133
May ...	74.8	76.6	78.9	87.9	82.2	79.0	77.6	79.3	80.3	85.3	81.3	80.3	17.9	17.6	0.146	0.062
June ...	81.9	84.0	86.1	97.0	90.8	86.3	84.6	86.1	86.6	93.0	88.4	86.6	16.4	16.3	0.211	0.111
July ...	81.3	83.5	86.0	95.6	90.0	86.0	84.7	86.7	87.7	93.3	88.8	87.7	19.0	18.6	0.220	0.091
August ...	79.7	81.8	84.2	92.0	87.3	84.4	83.6	85.3	86.3	90.2	87.1	86.3	19.2	19.0	0.091	0.075
September ...	80.1	82.8	85.6	96.9	90.1	85.9	84.4	86.6	87.6	93.4	88.8	87.6	18.1	18.1	0.140	0.085
October ...	75.9	78.4	81.7	91.1	85.6	82.1	79.8	82.0	83.6	88.5	84.5	83.7	16.9	16.9	0.098	0.062
November ...	65.7	70.3	75.6	88.9	80.5	76.0	70.8	74.3	77.1	82.2	77.8	77.4	14.4	14.3	0.078	0.078
December ...	60.0	63.8	69.0	78.1	71.6	69.2	64.0	67.4	70.4	74.2	70.3	70.6	14.1	13.9	0.048	0.050

NOTES :—(1) USA open pan Evaporimeter installed in the meteorological enclosure ; height of the rim of the evaporimeter is 14" from ground level ; readings are taken only on non-rainy days.

(2) Piche Evaporimeter installed inside the Stevenson Screen at a height of 4' from ground level. Values converted from ccs. to inches as per I.M.D. circulars.

(3) The records of the USA open pan and Piche evaporimeter are not comparable : the former is read only on non-rainy days whereas the Piche Evaporimeter is recorded daily.

Table 12 : Hourly distribution of rainfall (in inches) at Tocklai

	Rainfall during the hours (Tea Time)							Data not available (?)	Total rainfall
	0800-1200	1200-1600	1600-2000	2000-2400	2400-0400	0400-0800	Total		
April 1953 to December 1954 ..	15.38	7.91	9.34	21.64	38.55	34.44	127.26	11.63	138.89
1955 Jan. ...	0.12	0.11	0.02	0.06	0.16	0.00	.47	—	.47
Feb. ...	0.09	0.01	0.00	0.06	0.01	0.07	.24	—	.24
Mar. ...	0.34	0.07	0.77	0.94	1.46	1.10	4.68	—	4.68
Apr. ...	0.48	0.62	0.15	1.17	1.86	1.72	6 00	.81	6.81
May ...	1.19	0.98	0.76	0.85	1.46	1.61	6.85	3.12	9.97
June ...	2.55	0.27	0.31	0.57	3.50	2.11	9 31	1.25	10.56
July ...	1.40	0.88	2.23	2.34	2 17	1.62	10.64	1.53	12.17
Aug. ...	0.49	1.69	3.14	2.25	1.42	4.76	13.75	5.80	19.55
Sept. ...	0.34	0.96	0.16	0.39	2.99	2.02	6.86	1.94	8.80
Oct. ...	0.37	2.22	0.80	1.67	1.87	1.76	8.69	2.41	11.10
Nov. ...	0.32	0.28	0.01	0.10	0.10	0.16	.97	.43	1.40
Dec. ...	0.07	0.02	0 00	0.56	0.02	0.00	.67	—	.67
1956 Jan. ...	0.01	0.02	0.09	0.39	0.39	0.13	1.03	—	1.03
Feb. ...	0.00	0.26	0.00	0.00	0 00	0.00	.26	—	.26
Mar. ...	0.31	0.14	1.62	0 66	0.78	1 01	4.52	—	4.52
Apr. ...	?	?	?	?	?	?	?	6.48	6.48
May ...	0.52	0.37	0.99	0.50	3.56	3.77	9.71	—	9.71
June ...	0.55	0.82	1.21	1.33	4.47	0.64	9.02	—	9.02
July ...	3.71	0.55	1.54	1.38	5.62	4.46	17.26	4 11	21.37
Aug. ...	0.35	0.62	0.22	2.59	3.56	2.79	10.13	—	10.13
Sep. ...	1.16	0.21	0.76	1.57	0 77	0.89	5.36	—	5.36
Oct. ...	1.83	1 50	0.01	1.09	1.79	0.04	6.26	—	6.26
Nov. ...	0.43	0.14	0.33	0.19	0.11	0.23	1.43	—	1.43
Dec. ...	0.32	0.00	0.02	0.08	0.14	0.16	.72	—	.72

NOTES : Tea Time is equivalent to Indian Standard Time plus one hour and is much nearer to the Mean Local Time at Tocklai.

(?) Instrument out of order.

Table 12 : Hourly distribution of rainfall (in inches) at Tocklai -(Contd.)

	Rainfall during the hours (Tea Time)							Data not available (?)	Total rainfall
	0800-1200	1200-1600	1600-2000	2000-2400	2400-0400	0400-0800	Total		
1957 Jan. ...	0 21	0.06	0.12	0.41	0.35	0.27	1.42	.13	1 55
Feb. ...	0.01	0.12	0.43	0.82	0.67	0.09	2.14	—	2.14
Mar. ..	0.01	0.00	0.33	0.25	0.12	0.09	.80	—	.80
Apr. ...	0.16	0.20	1.19	2.92	1.59	0.68	6.74	—	6.74
May ...	4.42	1.44	3.92	4.99	6.32	5.79	26.88	—	26.88
June ...	5.34	1.57	1.23	0.84	2.14	3.56	14 68	—	14.68
July ...	0.66	0.66	0.82	2.63	5.33	6.92	17.02	—	17.02
Aug. ...	1.94	0.15	0.53	0.99	4.03	4.81	12.45	—	12.45
Sep. ...	0.25	0.23	0.88	0.23	3.52	1.83	6.94	—	6.94
Oct. ...	1.03	0.16	0.00	0.89	1.12	1.78	4.98	—	4.98
Nov. ...	1.25	0.03	0.00	0.36	0.30	0.12	2.06	—	2.06
Dec. ...	0.09	0.00	0.00	0.51	0.08	0.03	.71	—	.71
1958 Jan. ...	0.22	0.00	0.06	0.02	0.03	0.02	.35	—	.35
Feb. ...	0.06	0.01	0.14	0.26	0.69	0.31	1.47	—	1.47
Mar. ...	0.00	0.01	0.00	0.00	0.02	0.04	.07	—	.07
Apr. ...	0.77	0 47	0.77	1.08	0.48	0.46	4.03	—	4.03
May ...	3.52	1.04	0.77	2.88	2.65	4 98	15.84	—	15.84
June ...	2.11	1.37	0.41	0.13	3.07	1.58	8 67	—	8.67
July ...	0.80	0.94	2 36	4.34	9.75	7.13	25.32	—	25.32
Aug. ...	1.16	1 63	2.57	4.70	3.16	2.13	15.35	—	15.35
Sep. ...	0.54	1.03	0.24	0.54	0.81	2.24	5.40	—	5.40
Oct. ...	0.70	1.19	1.93	0.88	1.43	0.51	6.64	—	6.64
Nov. ...	0.00	0.00	0.00	0.00	0.03	0.00	.03	—	.03
Dec. ...	0.13	0.02	0.20	0 00	0.39	0.03	.77	—	.77
1959 Jan. ...	0.16	0.40	0.09	0.40	0.14	0.10	1.29	—	1.29
Feb. ...	0.13	0.05	0.04	0.80	0.76	0.52	2.30	—	2.30
Mar. ...	0.53	0.12	0.25	1.04	0.83	0.11	2.88	—	2.88

NOTES : Tea Time is equivalent to Indian Standard Time plus one hour and is much nearer to the Mean Local Time at Tocklai.

(?) Instrument out of order.

Table 13 : Total duration of rainfall in hours at Tocklai

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Total
1955	6.35	7.82	32.05	27.77	35 47	56.42	81.97	57.35	40 53	30.65	28 68	3.63	408.69
1956	11.03	0.33	23.83	?	76 22	83 90	73.92	66.20	18.50	23.50	16.58	5.68	399.69
1957	35 53	32.48	4.92	34.10	130.42	42.83	87.73	64.85	33.10	24.65	12.30	7.35	510.26
1958	4.12	15.52	1.75	37.60	85.22	42 58	108.23	120.72	36 17	26.97	2 25	7.90	489.03
1959	20.48	30.28	19.45										70.21 (only for 3 months)

Note : Instrument out of order during the whole of April 1956 and also at other times (see table 12)

Table 14 : Rainfall (in cents) according to rain intensity (in cents/hour) at Tocklai

Month		Categories of rain intensity							Data not avail-able (?)	Total rain-fall
		0—40	40—80	80—120	120—160	160—200	Over 200	Total		
April 1953 to December 1954	...	4872	2859	2025	2213	436	838	13243	646	13889
1955 Jan.	...	47	0	0	0	0	0	47	—	47
Feb.	...	24	0	0	0	0	0	24	—	24
Mar.	...	309	87	72	0	0	0	468	—	468
Apr.	...	309	234	0	41	0	0	584	97	681
May	...	344	92	117	0	82	49	684	313	997
June	...	493	64	108	168	68	0	901	155	1056
July	...	576	244	112	14	0	126	1072	145	1217
Aug.	...	370	308	63	196	102	316	1355	600	1955
Sep.	...	287	128	0	0	80	222	717	163	880
Oct.	...	216	144	176	42	0	267	845	265	1110
Nov.	...	99	0	0	0	0	0	99	41	140
Dec.	...	13	0	0	54	0	0	67	—	67
1956 Jan.	...	65	38	0	0	0	0	103	—	103
Feb.	...	0	10	0	0	16	0	26	—	26
Mar.	...	155	80	96	54	14	53	452	—	452
Apr.	...	?	?	?	?	?	?	?	648	648
May	...	586	165	23	0	128	0	902	69	971
June	...	423	70	197	7	179	26	902	—	902
July	...	370	351	143	303	114	446	1727	410	2137
Aug.	...	307	145	134	175	168	35	964	57	1021
Sep.	...	118	25	133	0	61	191	528	—	528
Oct.	...	122	16	153	46	0	289	626	—	626
Nov.	...	110	9	0	24	0	0	143	—	143
Dec.	...	37	35	0	0	0	0	72	—	72

(?) Instrument out of order.

Table 14 : Rainfall (in cents) according to rain intensity (in cents/hour) at Tocklai—(Contd.)

Month		Categories of rain intensity							Data not available (?)	Total rainfall
		0—40	40–80	80–120	120–160	160–200	Over 200	Total		
1957 Jan.	...	132	0	10	0	0	0	142	13	155
Feb.	...	166	30	18	0	0	0	214	—	214
Mar.	...	28	12	21	19	0	0	80	—	80
Apr.	...	226	118	172	0	57	101	674	—	674
May	...	1249	697	498	46	0	198	2688	—	2688
June	...	237	155	216	657	0	203	1468	—	1468
July	...	496	217	434	178	149	228	1702	—	1702
Aug.	...	466	291	253	34	0	201	1245	—	1245
Sept.	...	210	67	86	0	211	120	694	—	694
Oct.	...	198	0	0	199	13	88	498	—	498
Nov.	...	71	68	67	0	0	0	206	—	206
Dec.	...	48	23	0	0	0	0	71	—	71
1958 Jan.	...	39	0	0	0	0	0	39		39
Feb.	...	143	0	0	0	0	0	143	—	143
Mar.	...	7	0	0	0	0	0	7	—	7
Apr.	...	272	58	37	36	0	0	403	—	403
May	...	570	307	339	33	91	244	1584	...	1584
June	...	291	139	28	71	246	92	867	—	867
July	...	635	573	409	396	264	255	2532	—	2532
Aug.	...	729	304	105	0	64	333	1535	—	1535
Sep.	...	248	135	106	51	0	0	540	—	540
Oct.	...	165	45	243	50	0	161	664	—	664
Nov.	...	3	0	0	0	0	0	3	—	3
Dec.	...	48	29	0	0	0	0	77	—	77
1959 Jan.	...	135	0	0	0	0	0	135	—	135
Feb.	...	204	2	18	0	0	0	224	—	224
Mar.	...	163	38	87	0	0	0	288	—	288

(?) Instrument out of order.

SILCOORIE SUB-STATION METEOROLOGICAL OBSERVATIONS, 1958
(Tables 15 to 18)

Table 15 :

Month		Mean temp. °F Max.	Mean temp. °F Min.	Sunshine in hrs.	Rainfall in inches.	No. of rainy days
January	...	79.0 (78 6)	53.8 (54.6)	7.5 (?)	1.29 (3.50)	3 (4)
February	...	77.9 (76.8)	55.0 (55.0)	6.9 (?)	4.05 (2.16)	10 (6)
March	...	90.0 (87.1)	60.6 (61.2)	7.9 (?)	0.07 (0.37)	1 (3)
April	...	90.9 (90.6)	69.3 (67.9)	7.3 (?)	5.96 (16 65)	14 (13)
May	...	87.8 (88.1)	73.4 (72.0)	5.4 (?)	24.84 (29.51)	20 (24)
June	...	91 0 (89.5)	76.8 (76.4)	4.6 (?)	16.73 (13.52)	21 (23)
July	...	91.0 (89.8)	77.4 (76.7)	5.3 (4.6)	15.58 (27.36)	31 (30)
August	...	88.3 (?)	76.8 (?)	3.9 (5.2)	17.42 (13.10)	28 (22)
September	...	91.0 (89.2)	76.3 (75.6)	5.4 (5.2)	10.39 (19.51)	18 (17)
October	...	88.2 (87.4)	74.7 (69.9)	5.6 (7.7)	8.91 (4.33)	13 (8)
November	...	86.2 (85.3)	62.4 (61.2)	8.2 (9.1)	0.07 (0.00)	1 (0)
December	...	79.9 (79.9)	56.1 (54.0)	7.4 (8.3)	1.01 (0.00)	3 (0)
Total	...				106.32 (130.01)	163 (150)
Average	...	86.8 (85.7)	67.7 (65.9)	6.3 (6.7)		

NOTE :—Data in brackets show 1957 figures.

Table 16 : % Relative Humidity, monthly averages

Hrs. I.S.T.	Jan.	Feb.	Mar.	Apr.	May	June	Jul	Aug.	Sep.	Oct.	Nov.	Dec.
06 19	97 (96)	94 (93)	90 (93)	88 (88)	89 (91)	92 (93)	94 (95)	94 (94)	93 (92)	96 (94)	92 (95)	97 (97)
13 19	45 (54)	47 (45)	34 (38)	49 (48)	69 (71)	70 (72)	69 (73)	77 (68)	73 (69)	71 (61)	50 (47)	49 (44)

Table 17 : Vapour tension, monthly averages, in inches of mercury

Hrs. I.S.T.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.
06 19	0.417 (.425)	0.433 (.421)	0.516 (.523)	0.697 (.654)	0 811 (.778)	0 917 (.894)	0.934 (.920)	0.917 (925)	0.901 (.861)	0.867 (.737)	0.562 (.539)	0.457 (.417)
13 19	0.417 (.447)	0.417 (.404)	0.445 (.451)	0.657 (.638)	0.835 (.830)	0.930 (.902)	0.952 (.925)	0.955 (.920)	0.962 (870)	0.864 (.740)	0.572 (.533)	0.472 (.424)

NOTE :- Data in brackets show 1957 figures.

Table 18 : Soil temperature °F and Evaporation from Piche Evaporimeter, monthly averages

Month	Soil temperature in Bare Plot °F						Evaporation from Piche Evaporimeter in inches (1)
	06 19 hrs. I. S. T., at depth.			13 19 hrs. I. S. T., at depth			
	5 cms	15 cms.	30 cms.	5 cms.	15 cms.	30 cms.	
January ...	62.1 (61.8)	66.6 (65.5)	70.3 (69.0)	78.8 (77.6)	71.8 (70.2)	70.7 (69.1)	0.094 (0.075)
February ...	61.9 (62.8)	66.2 (66.9)	69.6 (70.4)	78.6 (80.6)	71.2 (72.0)	69.8 (70.5)	0.111 (0.089)
March ...	70.2 (69.8)	75.0 (74.5)	78.8 (77.9	90.9 (91.6)	81.5 (80.9)	79.0 (78.1)	0.212 (0.158)
April ...	76.6 (74.8)	80.4 (78.6)	83.7 (81.9)	95.4 (94.6)	86.7 (85.0)	84.0 (82.5)	0.169 (0.173)
May ...	77.9 (77.1)	80.2 (79.9)	82.6 (82.3)	92.3 (89.9)	85.3 (84.4)	83.1 (82.5)	0.101 (0.104)
June ...	83.3 (80.9)	85.8 (82.7)	88.5 (84.9)	98.6 (93.4)	90.9 (87.8)	88.7 (85.3)	0.094 (0.083)
July ...	82.8 (81.5)	84.7 (83.7)	87.4 (86.0)	97.0 (94.4)	90.1 (88.5)	87.8 (86.2)	0.088 (0.084)
August ...	81.1 (81.6)	83.1 (83.9)	85.3 (85.9)	93.6 (94.8)	87.8 (88.4)	85.8 (86.6)	0.068 (0.096)
September ...	81.5 (79.0)	83.8 (81.5)	86.5 (83.8)	95.5 (91.8)	89.4 (85.8)	87.1 (84.4)	0.088 (0.078)
October ...	79.5 (76.3)	81.9 (79.7)	84.6 (82.8)	93.0 (92.5)	87.1 (85.5)	85.3 (83.3)	0.065 (0.085)
November ...	70.7 (70.6)	75.6 (75.4)	79.3 (79.3)	90.5 (90.1)	82.8 (82.4)	80.1 (80.0)	0.091 (0.098)
December ...	64.4 (64.4)	68.9 (69.3)	72.9 (73.4)	82.0 (82.4)	74.8 (75.0)	73.4 (73.8)	0.072 (0.094)

NOTES :—(1) Piche Evaporimeter installed inside the Stevenson Screen at a height of 4' from ground level. Values converted from ccs. to inches.

(2) Data in brackets show 1957 figures.

BOTANICAL BRANCH

W. WIGHT—Senior Botanist

D. N. BARUA—Plant Physiologist

M. J. GREEN—Selection Officer

P. K. BARUA—Additional Officer

STAFF

Dr. W. Wight was on local leave 11th to 15th January. Dr. D. N. Barua was on long leave in India 11th March to 13th October. Mr. M. J. Green was on local leave 23rd December until 5th January, 1959. Mr. P. K. Barua did not take leave. Dr. Wight acted for the Director, during the latter's absence on leave and tour, for 126 days.

RESEARCH AND EXPERIMENT

Systematic Botany :

It was shown last year (1957) that leaf sclereids are important for the classification of tea. Research along these lines, based on collections by the late Capt. Kingdon-Ward, suggested an introgression of sclereids from *Camellia irrawadiensis*, a species with an intense development of large sclereids. This work is now in the technical press. During the year under review (1958) it was found that sclereids are characteristically absent, or almost so, in the type variety (*C. sinensis* var. *sinensis*). Sclereids are present in var. *assamica* and in the Southern form of tea described by Roberts *et al* (*New Phytol.* 57, 211, 1958) but the form of the sclereids differs between the two taxa. This part of the investigation is being prepared for publication. Other aspects, completed but not yet summarised, are, firstly, the relation of these vegetative (and chemical) features, to the ovary and disc of the flower: this has a most important bearing on the natural affinities of the taxa, and particularly on their status under the international code, and nothing on this subject has been published that does not need revision. In the second place is the significance of vegetative features in

terms of the crop-yield possible in the presence of nitrogenous manures and shade-trees. It is proposed to deal with this aspect first, and to this end a review of the responses of tea populations to manures and shade-trees is included in the present report.

Breeding :

In spite of several set-backs previously recorded, tea breeding is now ahead of the Association's original programme, drawn up in 1947. As the first phase was scheduled for completion in 1960 it will be convenient to report at length after that date and refer briefly here to the finding, in 1958, that the yield of progeny populations may or may not be increased by shade (reduced light intensity). Two populations were tested: the yield of one was increased by shade, but the yield of the other was not altered. The economic significance of the phenomenon is discussed in detail in the latter part if this year's report (*vide infra*).

Illumination and Nutrients :

Past research on Sau trees (*Albizzia chinensis*) and fertilisers has been reviewed during the year with the object of making known the salient features of the system under which tea is cultivated. This knowledge is necessary for the breeder and for all who wish to group tea plants and tea populations in categories with practical meaning. It is particularly necessary to know the relations, if any, which exist between the yield increments obtained under Sau, or other shade-trees, and those got by a mere reduction of illumination intensity (*vide supra*). The subject is reviewed in this report under the heading "The Shade-tree Tradition in Tea Gardens of north-east India."

Selection by Estate Managers :

An important part of the year's work has been the selection of bushes for propagation on tea estates under the guidance of the Selection Officer (Mr. M. J. Green) whose activities in this direction are summarised under the heading of "Advisory and General." Mr. Green's impressions of vegetative propagation in Ceylon are of special interest and they are therefore given

at length in the form of an article entitled "Vegetative Propagation of Tea in Ceylon."

PUBLICATIONS

Barua, P. K. and Wight, W. Leaf sclereids in the taxonomy of *Thea* camellias: 1—Wilson's and related camellias. *Phytomorphology* **8** (3.4): 257-264 (1958).

Roberts, E. A. H., Wight, W. and Wood, D. J. Paper chromatography as an aid to the taxonomy of *Thea* camellias. *New Phytol.* **57**(2) : 211-225 (1958).

Wight, W. Life expectation of Indian tea plantations. *The Commercial Times* **8** (1) : 31-36 (1958)

Wight, W. The agrotype concept in tea taxonomy. *Nature* **181** : 893-895 (1958).

Wight, W. Agrotype concept in chemical analysis of tea. *Nature* **181** : 1355 (1958).

Wood, D. J. and Barua, P. K. Species hybrids in tea. *Nature* **181** : 1674—1675 (1958).

TEA ENCYCLOPAEDIA SERIALS

Green, M. J. The indexing of Tocklai clones. Serial **2/1**, revised.

Green, M. J. Selection nurseries. Serial **125**.

Green, M. J. Basic programme for selection and propagation. Serial **126**.

Green, M. J. Clonal trials and records. Serial **127**.

Green, M. J. Nucleus clones. Serial **128**.

Green, M. J. Field selection methods. Serial **129**.

ADVISORY

Touring.— The Additional Officer (Mr. P. K. Barua) visited Ging T. E. in Darjeeling in connection with tea classification in relation to quality and flavour. Other than this item, the work described below is entirely that of the Selection Officer (Mr. M. J. Green).

. Fifty-eight estates were visited in connection with vegetative propagation and seed baries. These were distributed as follows:—

Assam Valley	...	30	estates (Some estates visited more than once).	
Cachar	...	6	—do—	—do—
Dooars	...	18	—do—	—do—
Terai and Darjeeling	...	4	—do—	—do—

A visit was made in March to South India, to attend the 6th Annual Conference of the United Planters' Association of S. India (Tea). In the course of this visit two estates were visited, as well as the U.P.A.S.I. laboratories and experimental plots.

A symposium on Replanting and Rehabilitation held in Colombo was attended in November and the opportunity was taken of visiting eight tea estates in Ceylon, as well as the Tea Research Institute at St. Coombs and two clonal proving stations.

GENERAL REMARKS

One hundred and twenty pounds of seed was distributed to Assam, Cachar, and Dooars, in connection with the trial of Stock 367 seed. Further samples of this seed were also sent to estates in Darjeeling. Arrangements are in hand to start the distribution of eight vegetative clones during 1959.

Lectures.— Four talks on selection methods were given to planters in the Dooars in June, and an address entitled "The Principles and Methods of Selection" was given to a meeting of the Tea Planters' Society at Panitola Club in November. Lectures were also given during the Lecture Courses in February/March, and during the Vegetative Propagation Course in November.

Correspondence.— Three hundred and seventy-six letters were written during the year, of which 111 were to tea estates giving advice on selection.

VEGETATIVE PROPAGATION OF TEA IN CEYLON

BY M. J. GREEN.

Introduction :

This article is based upon notes compiled during a visit to Ceylon made in November, 1958. The primary object of this visit was to attend the Symposium on Tea Rehabilitation and Replanting held in Colombo on 28th November, 1958, but the opportunity was taken to visit eight tea estates as well as the Tea Research Institute of Ceylon's laboratories and experimental estate at St. Coombs, with two of its subsidiary clonal proving stations.

During the course of this tour, vegetative propagation was only one of the aspects of tea culture which were considered and, furthermore, it is not possible to assess accurately the extent to which the methods and progress observed can be taken as typical of Ceylon. It is likely, however, that these estates are above average in most respects.

The need for clonal replanting :

Most of the tea planted originally in Ceylon still survives, much of it in a very healthy state. Ceylon is not free from pests and diseases, however, and there is constant infilling because of attacks by *Poria*, Shot-hole borer, Eelworm, etc.

Nowhere in Ceylon, however, has there been an annual replanting programme, and the seed required for infilling and extensions has been supplied by small *baries* (orchards) that are inefficient by Assam standards. There has been no competition between seed producers like that responsible for the production of the better Assam *jats*.

Now, however, it has come to be realised that much of the tea could profitably be replaced and the immediate question is with what. Such seed as can be obtained is not very good.

Only clones could be considered under these circumstances, and so the Tea Research Institute of Ceylon (T.R.I.) has for several years been conducting a search for suitable clones and perfecting methods of vegetative propagation. Many tea estates have conducted their own selection schemes, under the advice of the T.R.I., and it is possibly true to say that many progressive estates have, to some extent, propagated tea vegetatively.

There has recently been introduced by the Ceylon Government, a Tea Rehabilitation and Replanting Scheme. This scheme envisages estates replanting 6% of their acreage over the next 6 years, this with clones. There will be a general cess on all estates towards the cost of the scheme, this cess being Re. 1/- for every 25 lbs. of tea they produce. From this fund, estates will be paid Rs. 2,500/- for each replanted acre up to 6% of their acreage.

It nothing else, this scheme is bound to give a great impetus to clonal replanting in Ceylon, and it is certain that the areas so replanted will yield more heavily and produce better quality teas than under the populations the clones replace.

Clonal selection methods :

There is a strong element of the China variety (*Camellia sinensis* var. *sinensis*) in Ceylon tea estates and, in addition, an unusually strong element of the Southern form recently described by Roberts, Wight and Wood[1]. It is doubtful whether pubescence could be used as a criterion of quality as it is in Assam[2]; nor has pubescence special value in the form of "tip" in high elevation flavoury teas. In any case these teas are given such a hard roll during manufacture that tip is virtually eliminated and mainly broken grades are produced. There could, no doubt, be a place for pubescence in the low country estates, where leaf-grades are produced, but this would only be for appearance.

No visual criterion of quality has been developed in Ceylon, and field selection is confined to the consideration of vigour. On most estates the initial selection is carried out by the pluckers,

the Manager or Superintendent then checking the selected plants himself.

The following characteristics are noted by Visser and Kehl[1] as being undesirable and warranting the rejection of a bush:

1. A open plucking table.
2. Carrying few plucking points.
3. An upright habit or poor spread.
4. Having few maintenance leaves.
5. A free flowering habit.
6. A tendency to produce dormant shoots (*banjhi*) frequently.
7. Very short internodes.
8. Slow recovery from pruning.

After rejection of bushes having any of these characteristics, the Manager or Superintendent would finally pick out those of the remaining bushes which appear likely to be heavy yielders. Towards this end, the Ceylon planter is advised to record the yield of each of the remaining bushes round by round for eight rounds of plucking and out of each 100 bushes reject the 50 lowest yielders. After the next 8 rounds, of the 50 bushes left, a further 25 will be rejected; then another 8 rounds rejecting 8 of the remaining 25, and a final 8 rounds rejecting 6 of the remaining 17. Thus for each 100 bushes originally selected in the field, the 11 highest yielders will be selected[3].

At this stage the planters are advised to manufacture and taste leaf from each bush, using a mincing machine as a roller. The impression was gained, however, that it is in fact, not general for this to be done, and in most cases the selected bushes would at this stage be propagated and a rooting trial initiated.

Rooting trials are neither replicated nor randomised, but a given clone is likely to be put into a rooting trial on more than one occasion. In fact this means that the beds used to propagate clones for multiplication plots (*i.e.* nucleus clones) are used as a rooting trial.

Multiplication plots are then planted with such clones as pass the rooting trial or at least appear to root satisfactorily. These plots also serve as trial plots and, in general, consist of a single row of plants running up and down the slope of the hill. Again these plots are rarely replicated, and as a clone becomes rejected so it is likely to be uprooted and that plot space utilised for another clone.

In the trial plots, whether these are separately planted or are multiplication plots as described above, yields are recorded from each clone and the figure expressed as a yield per acre by multiplying by the appropriate factor. Thus if a plot consists of 100 bushes and it is estimated that an acre contains, on the average, 5,000 plants, then the plot yield would be multiplied by 50.

By this method it is hoped to obtain yield figures which not only will enable different clones in one trial to be compared, but which will also permit the comparison of clones on different estates or in different years. This aim is rendered difficult of attainment because of the fact that one-row plots cannot give accurate comparative yields. A vigorous clone can easily grow to such an extent that a neighbouring clone is unable to develop fully. Such a state of affairs is exaggerated when the clones in a trial are of different ages. Thus on more than one occasion a single row of one year old plants was seen struggling for light and space between two vigorous five year old clones.

At this stage further tasting is required, and it is general to see being used scale models of orthodox rollers. Some of these rollers are remarkable for the accuracy with which they have been constructed to scale. Such rollers take 1 to 3 lbs. of withered leaf and are able to produce teas virtually indistinguishable from ordinarily manufactured tea, even down to producing the various grades.

It is debatable whether the teas produced by these rollers are any more suitable for tasting than are teas produced after rolling in either a mincer or a "Pizey" roller, and their use places a limit on either the minimum size or the minimum age of the plots from which the leaf is plucked.

The standard, or "control" used in assessing the suitability of estate clones is almost invariably one or more of the T.R.I. clones such as 2023 and 2024. These clones are noted for their extreme vigour combined with useful quality. I am not aware of any estate clone being more vigorous than these and there appears to be a tendency, consequent upon using such clones as controls, to discard clones which, although possessing good quality and vigour, do not quite come up to the standard of vigour set by these T.R.I. clones. At Tocklai it has been said that "the control should be of that *jat* or clone upon which it is desired to improve by clonal selection[1]". It is to be feared that, as a result of not fully understanding the principles involved, Ceylon planters have perhaps discarded quite a large number of clones which could, in fact, be of great value.

Long-term trials do not commonly seem to be planted and on several estates the unsuitability of a clone was only discovered after several acres of plucking tea had been planted. However, some planters appear to look upon these sections as long-term trial plots and deliberately plant the clones in blocks of 1-2 acres for this purpose. Generally the necessity for obtaining more accurate yield figures than had previously been obtained from trial plots was given as the reason for this planting.

In Ceylon, as in Darjeeling, it is possibly true to say that no single bush has true Ceylon flavour. Rather such flavour may be the combination of flavours from several bushes. Nevertheless only on one estate did any experimental blending appear to have been attempted. In this case, leaf of one of the T.R.I. clones had been blended in various proportions with the estate's normal bulk tea and of the various samples the one of which combined 60% clonal leaf with 40% bulk tea, the percentage figures relating to weight of withered leaf, was preferred by the taster.

The efforts being made in Ceylon to select new clones are appreciable and should not be ignored, and a very large number of estates are selecting their own clones and testing them along with T.R.I. clones. At the same time the T.R.I. is setting up a series of clonal proving stations at which their own and estate clones will be put out for trial to test their suitability for the various districts. Estates may send their clones to the T.R.I.

for testing at these stations after having completed their own trials relating to rooting, yield and quality. This will be discussed further when consideration is made of distribution.

Propagation techniques:

The time at which cuttings are taken in Ceylon usually depends upon climatic factors, especially those which govern the time at which the clonal plants will be finally planted into the sections, or "fields", of plucking tea. Thus there is no general propagation period, except loosely within districts having the same climate.

Mostly, however, cuttings are taken two or three times a year, the bushes being cut across after the stems have been removed for cuttings, but on at least one estate the taking of cuttings is virtually a continuous process, sufficient cuttings being taken at any given time to fill such propagation beds as have become available as a result of transplanting the young clonal plants.

Even when cuttings are taken at predetermined periods, either all the stems from some bushes are used for cuttings, or else on each bush only those stems which are best developed are used.

The importance of climatic factors is more readily understood when it is realised that Ceylon is influenced by both the S. W. Monsoon, which lasts from May to August, and the N. E. Monsoon, which lasts from September to November. The importance of each monsoon is itself modified by geographical factors, so that there are districts which are affected by only one or other of the monsoons and other districts which are affected by both.

Superimposed upon effects of monsoon are effects of elevation, and these latter effects are sufficiently marked to warrant the classification of Ceylon tea estates into three groups depending upon the elevation of the factory. The classification is as under :—

(*a*) Up to 610 m. (2,000').
(*b*) 610 m.—1220 m. (2,000'—4,000').
(*c*) Over 1220 m. (4,000').

These groupings are fairly discrete and broadly speaking it may be said that the low-country estates have high yields with little flavour, the mid-country estates have low yields with little flavour, and the high elevation estates have high yields and also good flavour. The kind of made tea also varies, and whereas the higher elevation estates roll hard and produce mainly broken grades, low-country estates make leaf-grades.

Most of this is by way of digression, but it can be seen that climatic factors are very important and profoundly influence many aspects of clonal propagation, both in terms of technique and in terms of kind of plant selected.

The impression was gained that the elaborate precautions which are taken in Assam and other parts of north-east India to protect cuttings from sunshine are not necessary in Ceylon. There, the cuttings were being taken in full sunlight, being carried from mother bush to propagation bed in buckets of water and being planted in the beds in the heat of the sun at mid-day. Admittedly the planted cuttings were covered quite soon afterwards, but it was most striking to observe the lack of shade given to these cuttings in transit to the nursery.

Furthermore the propagation beds are generally not made up until about a week before the cuttings are planted. In fact on one estate the beds were being completed on the same day as the cuttings were due to be planted. Although the soil in these beds was tamped down, it was an easy matter to pick up a handful of soil and seive it through one's fingers. In contrast, beds in north-east India may frequently be walked over without impressions being made on the soil, so great is the degree of compaction.

The soil used in propagation beds is usually imported from some other part of the estate, and the best soil is that which has been under Guatemala grass for 3—6 years. Where this is not available a good substitute appears to be subsoil mixed with imported peat, with or without some added river sand. Certainly ordinary tea soils are inferior to these.

The cuttings are planted directly, without the use of a dibble, and are spaced very close together. Most estates visited had their cuttings spaced about 6″ × 1″, but this is not the spacing recommended by the T.R.I, which is about $3\frac{1}{2}$″ × 2-$2\frac{1}{2}$″. This close spacing is only possible because the cuttings, as soon as rooted at the age of about 2—5 months, will be transplanted into baskets. Where transplanting directly from the propagation beds into the field is practised the cuttings are spaced about 6″ × 6″.

In north-east India, the stems of cuttings are all the same length, this being effected by making an upper and a lower cut for each cutting. In Ceylon, on the other hand, the upper cut of one cutting is the lower cut of the one above it. This makes for more rapid work, but also results in a variation in stem length from $\frac{1}{2}$″ to 3″.

Once the cuttings have been planted they are then shaded. Shade is effected by either of two methods. The best method is the use of open weave coir net. This has a $\frac{1}{8}$″ weave and is supported over the beds by curved metal hoops. The complaint was heard that this is an expensive method, but in fact the coir costs only Rs. 1/- per square yard for normal quality and Rs. 2/50 for best quality, and may be expected to last for 3 years.

The alternative method of shading is to use fronds of the fern *Gleichenia linearis*. This is a cost-free method of shading, but is disadvantageous in that the shade so provided is never regular, either from estate to estate or within one propagation bed, nor can the cuttings be readily inspected. In contrast, the coir provides excellent shade and is easily lifted or rolled back over the metal hoops for inspection purposes. It is, moreover, likely that sufficient fern for large scale propagation would be difficult to obtain on many estates.

Transplanting :

It has already been stated that rooted clonal plants are most commonly basketted when 2—5 months old. The trans-

planting medium is usually richer than the soil in the propagation beds and a typical mixture observed consisted of either 4 parts red subsoil and 1 part compost or 2 parts jungle earth and 1 part sand. To either of these mixtures, measured in baskets, is added 1 cigarette tin of sterilised animal meal. The T.R.I. manuring recommendation is an application of 2 oz. Sterameal per 20 plants every two months or a monthly application of their "175" mixture, which contains 100 parts sulphate of ammonia, 50 parts Saposphosphate and 25 parts of 60% muriate of potash.

The basketted plants are kept under fern shade, which is gradually thinned but rarely completely removed, and then at some convenient time the plants are moved into the field. The age of the young clonal plants when this stage is reached will depend partly upon the size of the plants and partly upon climatic considerations. Thus where the N. E. monsoon is dominant this final transplanting is done in October to December whereas in other areas, such as those which get both monsoons, it is done in May to July during the S. W. monsoon.

Since cuttings will have been taken at various periods, the age of the plants when finally transplanted into the field is likely to vary considerably, and on one estate it was observed that such plants varied in age from 6—15 months.

The shading of young tea plants in the field is most commonly and, as has been demonstrated by experiments carried out by the T.R.I., best effected by fern fronds These need no attention and eventually the tea plants grow out of the shade. This fern is a hill species, and is not to be found in Assam tea estates.

Distribution of clonal material:

The Ceylon planter is not averse to rivals planting his clones and there is a considerable market for cuttings, which are sold at about 2½ cents each. At one time the price obtained by one estate was 10 cents per cutting, but this appears to have been rather exceptional, even if extremely profitable.

Apart from cuttings which estates may purchase from other estates, cuttings are also sold by the T.R.I., again at about 2½ cents each.

The T.R.I. has selected a large number of clones but not all of these have proved successful on all estates or in all districts. This has been found to be true in north-east India in the case of Tocklai clones and is to be expected. In order, therefore, to test clones for their district suitability, the T.R.I. has established district clonal proving stations at which T.R.I. clones and estate clones that have already passed their rooting, yield, and quality tests can be put out for trial. Cuttings of estate clones which are consequently proved to be suitable can then be sold by the T.R.I. to any other estate.

Thus any given estate is likely to be testing its own clones, T.R.I. clones and clones from other estates. This state of affairs is likely to lead to a large variety of clones being grown in a district much earlier than could otherwise be possible.

General:

Much is heard of clones in Ceylon giving fantastic yields. In fact one estate has reported a clone yielding 55 maunds per acre in its third year. If such a yield were truly valid, then it would not be surprising if the clone in question were used to replace all the existing tea in Ceylon.

Such yields are obtained by considering small plots, of one or two lines of plants only, within which the individual plants have, by virtue of being adjacent to younger or less vigorous clones, or even adjacent to a vacant plot, been able to spread to a very much greater extent than would have been possible had the plot been rectangular and large.

Yields from established *sections* of clonal tea do not support these figures. On one estate a section of 5 year old clonal tea yielded 17 maunds per acre, whilst on another estate two T.R.I. clones in their 6th year (3rd year in yield) gave 33 and 36 maunds per acre respectively.

These yields are extremely good, especially when it is considered that such estates have an average yield of 12—15

maunds per acre. Admittedly there is a tendency to apply large quantities of fertilisers, and 240 lbs. N. per acre applied during a 2 year cycle is not unknown, and it should also be remembered that these are the best yields, otherwise they would not be quoted.

The amount of clonal planting so far completed in Ceylon is about the same as in north-east India. This is very commendable in view of the fact that replanting as is known in north-east India is not practised in Ceylon, but, in view of the ease with which vegetative propagation can be carried out in Ceylon, its might also be said that it is surprising that more has not been done.

Whereas 90% rooting in north-east India is taken to be a relatively outstanding figure, such rooting is common in Ceylon. There are two factors which combine to enable cuttings in Ceylon to root easily: one is climate and the other is *jat*. At Tocklai it is found that the more "Chinary" *jats* root more readily than do the Assam *jats*, and it is this which lends support to our belief that vegetative propagation in Darjeeling could be more successful, or easier, than in the plains. It is also to be expected that the cooler conditions which operate in Ceylon during the monsoons help cuttings to become established; and it is well known that one of the difficulties experienced in Assam, in spite of high humidity, is the drying out of propagation beds, or at least a lowering of the humidity of the air under the lath frames, caused by the sun: this is particularly pronounced when the beds are not prepared well in advance of setting the cuttings.

The introduction of the Tea Rehabilitation and Replanting Scheme will undoubtedly lead to a rapid increase in the area under clones in Ceylon and in this respect it is well within the bounds of possibility that north-east India may be left far behind. At present, however, both regions appear to have advanced to the same degree and there is no valid reason why planters in north-east India should not at least keep pace with their counterparts in Ceylon, as there is as much clonal material available both in terms of acreage and in terms of number of different clones.

As a conclusion to this article, it is agreed that the comments of the Senior Botanist at Tocklai (Dr. Wight), who has followed botanical developments in Ceylon for many years, should be recorded here.

Dr. Wight says that it is surprising that clonal replanting was not done earlier in Ceylon. Twelve years ago, before Dr. F. R. Tubbs (Plant Physiologist at T.R.I.) left Ceylon, his knowledge of clones suited to Ceylon was much in advance of our knowledge of clones suited to Assam: furthermore, the botanical collections of tea in Ceylon were better than those at Tocklai. After Dr. Tubbs left Ceylon his work seems to have remained in abeyance until strenuous efforts by Mr. G. B. Portsmouth revived general interest in vegetative propagation about 1954. In early 1955 it was clear that good clones had remained unused for many years, at least on some estates. At that time Assam planters were ahead in their application of vegetative propagation to estate practice. Now it seems that the work is equally advanced in both countries, and this suggests that the efforts in Ceylon have recently been greater than those in India.

Nurseries and replanting being something of a novelty in Ceylon there may be less of the prejudice in favour of seed that is commonly justified in Assam by imputing greater difficulty to the technique of vegetative propagation. At the beginning of the Indian tea industry the Government of India contemplated the introduction of vegetative propagation. In Ceylon the matter has been clinched by the simultaneous introduction of replanting and vegetative propagation: this could conceivably establish a supremacy of Ceylon teas in the world market.

There are other, relevant, matters to consider. Among Assam tea planters there is a common, though unwarranted, belief that quality is dependent upon a certain "type" of leaf, and thus excellent clones may be rejected, or at least despised, because they do not possess an acceptable shape or colour of leaf. There would be no such difficulty in getting clones accepted in Ceylon.

The Assam variety of tea plant is not native to the *plains* of Assam and is, in general, unsuited to large scale cultivation

in many so-called tea areas. Other populations and clones, not typical of the Assam variety, are better suited to cultivation in many estates; but the plants look different and would often be unacceptable, even though they make the Assam kind of tea expected from the Brahmaputra valley, and in spite of possibly better quality.

In Assam one is faced with a situation where the possibility of improvement is generally accepted only within the limits of a fashionable shape of leaf. Were planters more willing to accept other shapes of leaf, then it would be easier to introduce clones which are better suited to the plains of Assam, and which would compare favourably in ease of propagation with the T.R.I. clones Nos. 2023 and 2024, the characteristics of which are well known at Tocklai. It can be noted that the shape of the leaf has little or no bearing on the finished product.

Dr. Wight fully agrees with the observation made in the above article that vegetative propagation in Ceylon (and Darjeeling) seems to need less care and attention than it does in the plains of Assam. But the care and attention is neither expensive nor difficult; and if comparable clones were to be grown in Assam then comparable levels of success could no doubt be attained. An important factor in Assam is an appreciable restriction of effort to plants and clones of fashionable appearance but fundamentally difficult to propagate and cultivate: this seems an unnecessary restriction, which, fortunately for Ceylon, is absent in Ceylon. Clones with markedly different types of leaf are now being distributed to members of the Association and it is to be hoped that they will be given a fair and impartial trial.

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THE SHADE-TREE TRADITION IN TEA GARDENS OF NORTHERN INDIA :

I—THE VALUE OF SHADE

BY W. WIGHT.

Tea is made from *Camellia sinensis* and its hybrids. In India the crop is grown in plantations of the order of 500 to 1,000 acres. These plantations are registered as "Estates" and known colloquially as "Gardens" but in Ceylon they are always called "Estates". Shade-trees have been used in both countries, but principles governing their use have been investigated only in India and there only after the growth of popular traditions not necessarily in accordance with fact. In this article the growth of tradition will be examined, and the effect of one species of shade-tree, on the yield of the tea bush, will be compared with the effect of an artificial reduction of light intensity.

Early observations

Extensive forests were cleared to make way for the tea gardens of Assam. The first gardens were planted with the introduced type variety known as the China tea plant, but at the same time the indigenous var. *assamica* was found growing wild under forest conditions. It was perceived that the shade of forest trees might be beneficial for the growth of tea plants, at least for the Assam variety. Masters[10], writing in 1863 says the Assam plant "does not appear to thrive in the inferior soils when exposed to the full influence of the sun." He recognises the possibility of different forms of tea plant having different shade requirements, but regards the question as not settled, and says "in a tea garden I would recommend partial shade".

Later comments (1903) by Watt and Mann[16] on the presence of trees such as *Ficus* suggest that a number of species had been left from the original forest by those who believed in or tolerated a tree canopy though this would not always be on account of shade, because the shooting of wild pigeon that feed on *Ficus* fruits has long been a diversion of tea planters.

According to Watt and Mann definite benefits of the Sau tree of Assam (*Albizzia stipulata* syn. *A. chinensis*) were made known by Col. Hannay of Dibrugarh, and in 1885 a pamphlet by Buckingham[2], published by the Indian Tea Association in Calcutta, gave sanction to this species as a shade tree.

The growth of tradition

From the account given by Watt and Mann, it appears that Watt was the first (1895) to ascribe the benefits of the Sau tree to its root nodules.

Jointly however, Watt and Mann[16] were obliged to admit both the complexity of the relation between the shade tree and the tea bush, and the difficulty of deciding precisely what factors most benefit the tea plant: nevertheless, it was concluded that the benefit "can only rationally in chief part be attributed to the fixation of Nitrogen by the roots" (of the Sau tree). How the nitrogen passed to the tea bush was said to be a matter of conjecture, because the debris from the tree was considered unlikely to provide sufficient nitrogen to account for the observed benefit. Watt and Mann also noted that Bamber in Ceylon attached importance to the circulation of nutrients from sub-soil to top soil that takes place *via* fallen leaves, flowers, pods, caducous branches, and so on. Bamber apparently attached little importance to the nodules on Sau and gave emphasis to calcium added to the top soil by *Grevillea*. He favoured "slight shade in Ceylon" (*vide* Watt and Mann). To-day, *Grevillea* is used in Ceylon and legumes in northern India: south India more or less follows Ceylon practice.

Watt and Mann had in mind the possibility of a symbiotic relation between the roots of the tea bush and the Sau tree. Much thought was given to getting the benefit of the tree without its shade, the value of which was debatable and said to be harmful in some instances. It is to be noted that neither the possibility of a symbiotic relation, nor the function of the mycorrhizae of the tea bush, has been investigated in the fifty years following Watt and Mann's introduction to the subject.

Inorganic nitrogen fertilisers had been discussed in Ceylon and in this connection Sir John Lawes is quoted as saying that

they would deplete the soil of minerals, especially calcium, and therefore their use in Ceylon was inadvisable. Watt and Mann said this would apply with even greater force in India, and their strong recommendation for the use of vegetable matter, dung, and especially oil-cake, was remembered for many years. The possibility of not manuring under shade trees seems to have been overlooked and it became customary to use both shade trees and organic manure.

Between the years 1920 and 1930, chemists of the Indian Tea Association began to encourage the use of ammonium sulphate. The first trials of this, and other inorganic manures, were conducted in full sunlight without the use of shade-trees[4]. As shade-trees are generally used in tea gardens, many planters questioned the utility of the trials, and it is therefore of special interest to note that Nightingale and Kraus[11], in another Continent, had asked (1924) the question "Does light affect the fertiliser requirements of plants"? The First Chemist of the Indian Tea Association (H. R. Cooper) however, was in close touch with tea garden practice and working in collaboration with the Scientific Officer of the Jorehaut Tea Coy. (N. M Macgregor), Cooper was able to show that yield increases due to ammonium sulphate are greatly reduced under shade trees. This statement corrects an earlier account of the history of the investigation[18]. Later, Cooper set up a field trial (1936) where ammonium sulphate was used in full sun and under the leguminous tree *Albizzia chinensis*. It will be convenient to refer to this tree by its Assamese name "Sau" (pronounced like the English word "saw"). The trial was designed by Yates (Rothamsted) in collaboration with Cooper. An important feature is twelve progeny populations (*jats*) representing the full range of cultivated populations that could be referable to var. *assamica*. So far as is known, no other similar trial has been conducted anywhere.

Shortly before he retired Cooper wrote a handbook entitled "Nitrogen Supply to Tea". This valuable handbook, mentioned by Russell[14], has been widely read in India and its subsequent history is important in connection with our subject. In the first edition Cooper[5] gave a forecast of the nutrient-illu-

mination interaction likely to be shown by the tea bushes in his trial. Cooper's forecast is quoted in Table 1 together with the yield subsequently observed over a period of 10 years.

Table 1 : Cooper's forecast in maunds made tea per acre per year (1 maund = 80 lbs.). "Observed" is pounds green weight per 100 bushes spaced 4.5 ft. triangular and plucked at 32 weekly intervals per year. Mean annual dose of nitrogen 84 lbs. per acre.

	Predicted (1939)		Observed (1942 1951)	
	Sau trees	Full sun	Sau trees	Full sun
Ammonium sulphate	13	12	274	206
No fertiliser	9	6	230	116

Cooper's trial shows the yield increments due to Sau trees to be equivalent to those obtained from about 80 lbs. of nitrogen per acre per year. Statistical analysis of these results will be given in a later section: for the present it is sufficient to note that a satisfactory crop yield can be obtained by the use of shade trees alone, but if shade trees are not used then large amounts of nitrogenous fertiliser are necessary. Normal doses of ammonium sulphate do not exceed the equivalent of 100 pounds of nitrogen per acre. Without shade trees the yield increase is approximately linear, in simple proportion to nitrogen up to a dosage of the order of 120 pounds per acre. Not only is the return per pound of nitrogen less under shade trees, but deviation from a linear response can be expected at a lower dose of ammonium sulphate.

Cooper[5] said "the actual shade of the trees appears to be directly beneficial to the tea' but "probably one of the greatest advantages they offer is continuity of nitrogen supply."

In his purely practical treatment of shade and manures, Cooper, quite rightly, did not attempt to explain the interac-

tions he disclosed; and, in fact, a very likely explanation could be found in a paper by Clements[3] published in 1928 in answer to the question "Does light alter the fertiliser requirements of plants?" Clements showed that similar states of growth of field pea in controlled laboratory experiments could be attained under different illumination conditions only when the relative proportions of three nutrients were changed: the nutrients were calcium nitrate, magnesium sulphate, and di-hydrogen potassium phosphate. There was no implication that these nutrients are the only ones of importance: but the principle that comparable growth under different illumination conditions may necessitate an altered balance of nutrients, was demonstrated. One could not suppose the principle to apply only to the plant used by Clements.

In Clements work the illumination differences were complex and involved an increase of duration, as well as differences in wave length and intensity: nevertheless, one could have expected the principle to influence modes of thought about the illumination-nutrient interactions seen when tea bushes are growing under shade trees. Subsequent studies of illumination-nutrient interactions are too numerous to describe here, apart from those with a direct bearing on traditional belief about a shade tree canopy.

Interactions similar to that observed by Cooper were recorded by White [17] in precise experiments with *Lemna* in which the illumination varied only in intensity. At high light intensities increases of nitrogen caused increases of growth up to the highest nitrogen level, but at lower light intensities nitrogen doses were less effective. At the lowest light intensity the higher doses of nitrogen depressed growth. There was a strong indication that the lowest light intensity with minimal nitrogen could cause more growth than moderate nitrogen doses at a much higher light intensity.

White's work is of particular interest in that 'shade' was obtained by controlling the illumination intensity at its source; and it could not be concomitant with nitrogen additional to that supplied by the experimenter, as might happen when shade is obtained in the field by the use of living trees.

Editorial insertions in a third (1946) edition of Cooper's handbook[7] overlooked the interactions demonstrated by Clements and White and made the principle of diminishing returns a reason for suggesting that so much nitrogen is fixed by a leguminous shade tree that yield of the tea bushes will no longer be in simple proportion to nitrogen added as ammonium sulphate: this was supposed to be the reason for the comparative inefficiency of ammonium sulphate under shade trees. It is only fair to say that Cooper did not participate in any way in the preparation of the second[6] or the third[7], nor the subsequent reprint of the third edition[8], of the handbook which continued to bear his name. Editorial insertions (anonymous) in the third edition[7] implied that growth increments in response to nitrogen would be closely similar under different illumination intensities—a condition not supported by White's data, in which a reduced light intensity by itself diminished the return from high doses of nitrogen.

Repetition of the statements in a 1952 (Jorhat) reprint of the same handbook[8] indicated the opinion prevailing in northern India. In 1954 Dutta[9] suggested that trees other than legumes would be inefficient as shade, the value of a shade tree, as distinct from mere reduction of illumination, being dependent upon fixation of atmospheric nitrogen. However, it should be noted that nitrogen fixation by leguminous trees in tea gardens has not been examined.

Dutta's argument was reviewed by Portsmouth[10] who said "whether the benefits of natural shade are due merely to a reduction in light intensity, to extra nitrogen produced by fixation, or to a combination of both effects would thus appear to be still unsolved."

Various observations at Tocklai bear on the problem perceived by Portsmouth. These observations are lacking in statistical replication, largely because the requirement of mature trees and old tea bushes could be found only in trials designed for other purposes. The observations are in many ways incomplete but they are relevant to an appraisal of traditional belief and lead to hypotheses more in accordance with fact, and forming a more suitable basis for scientific investigation: this

alone is sufficient to justify publication of the work in its present state.

The effect of shade

In 1951 replicated plots each containing 21 bushes that had been growing in full sunlight for 31 years, were screened by a horizontal network of split bamboo held six feet above the bushes. The bamboo laths were approximately one inch wide with rhomboid meshes about 3.5 square inches in area. The light intensity, determined by photo-electric meter, was approximately 45% of full sunlight at midday in June. Neither the shaded nor the corresponding, unshaded, plots were manured in any way, yet the bamboo screens caused a yield increase. The mean annual increment was significant ($P < .05$) for each year and rose from 57% to 80% during the six year period of the author's observations (Table 2). It is evident that reduced illumination by itself causes a yield increase that must necessitate an increased uptake of soil nitrogen.

Table 2 : Effect of screens on yield, expressed as percent increase of shaded plots over check plots in four blocks. Mean yield of 100 control bushes is 1.37 pounds green weight per season of 32 plucking rounds. Block figures ignore fractions: mean percentage calculated from primary data.

Year	Block 1	Block 2	Block 3	Block 4	Mean percent increase
1951	25	58	53	100	57
1952	15	73	73	135	66
1953	38	69	72	95	67
1954	46	76	28	95	60
1955	29	103	75	155	84
1956	37	88	68	135	78

This experiment agrees with many others in giving no reason for supposing bamboo screens to be detrimental to the normal

growth of tea bushes. It is possible that yield might sometimes be greater were illumination subject to seasonal changes like those under a deciduous tree canopy : nevertheless it can be concluded that a reduced intensity of illumination (hereafter designated "shade") is an important factor associated with the presence of a tree. The differences between blocks in Table 2 suggest that soil conditions greatly influence the magnitude of the shade effect. It is important to note, here and in all that follows, that "shade" means comparative darkness, and does not necessarily imply the presence of a tree.

Other functions of the tree

Screens similar to those described were used in all our experiments. In this section particular reference will be made to the field trial commenced by Cooper. A light intensity of 45% under screens was considered comparable with the general light intensity prevailing at midday under the Sau trees in Cooper's trial as a whole; but the intensity near to the bole of a tree would be less than 45%, and in places, due to imperfect development of the canopy, would be considerably greater than 45%. The trees were 50 feet apart in a triangular spacing, and were fully grown when compared with bamboo screens.

In Cooper's trial both the Sau trees and the tea bushes were planted as seedlings in the cold season of 1936-37. Ammonium sulphate was used as a fertiliser on plots in full sun and under Sau trees. The design of the experiment is shown in Fig. 1 and an analysis of variance of crop yield is given in Table 3. The trend of yield from 1939 to 1951 is shown in Fig. 2. The median drop in yield is due to war conditions, proper supervision being resumed only in 1947. There had been changes in nitrogen dosage leading to an average dose of 84 pounds per acre per annum for the period in Fig. 2. Subsequently, in the experiments about to be described, the nitrogen dosage, as ammonium sulphate, was fixed at 100 pounds per acre per year.

In Cooper's trial, and in all our experiments, the tea bushes were pruned annually : this is the custom in north-eastern India. Pruning is done in the cold season, usually in December

Table 3 : *Cooper's trial. Analysis of variance of each of 12 year's yield, and analysis of variance of mean yield. Columns give "F" values greater than unity. One asterisk indicates significance at 0.05 level, two at 0.01 level, and three at 0.001 level. The ten year total is for the years of approximately constant yield shown in Fig. 2.*

	D.F.	1940	1941	1942	1943	1944	1945	1946	1947	1948	1949	1950	1951	Ten year total 1942—1951	
														"F"	"P"
Replicates J × N	2 3	3.09	1.07	1.38	1.78	1.65	...	...	1.50	1.42	1.18	1.20	1.54	1.26	>.20
Sau trees (S)	1	5.30	9.09*	18.80**	26.77**	34.84**	30.21**	35.98**	48.37***	58.46***	42.04**	34.29**	36.01**	39.08	<.01
J × S × N Error	3 2	...	...	...	...	...	...	...	...	...	...	...	...	...	
Sub-blocks	11	11.04***	12.94***	27.99***	41.08***	50.96***	53.06***	59.04***	63.49***	59.76***	34.61***	31.54***	44.24***	65.39	<.001
Nitrogen (N)	1	111.86***	239.99***	248.78***	272.07***	171.65***	168.43***	301.61***	356.28***	370.20***	131.70***	72.62***	155.60***	305.26	<.001
Seed source (J)	11	54.40***	50.37***	32.49***	21.26***	7.26***	7.43***	8.50***	19.70***	8.56***	2.06*	1.42	2.34*	10.67	<.001
S × N	1	10.28**	23.81***	31.19***	33.96***	18.47***	23.95***	31.61***	30.20***	46.59***	13.07***	11.23**	20.45***	35.77	<.001
J × S	11	1.29	1.23	1.04	1.07	1.98*	1.68	1.89	2.38*	...	...	1.40	...	1.21	>.20
J × N	11	2.75**	2.99**	2.19*	1.36	1.39	...	1.74	3.04**	2.15*	...	...	...	1.49	<.20
J × S × N	11	...	1.19	1.28	1.38	1.33	1.53	1.57	1.10	1.40	1.10	...	...	1.42	<.20
Error	86	...	...	—	...	...	...	...	...	...	...	...	...	...	

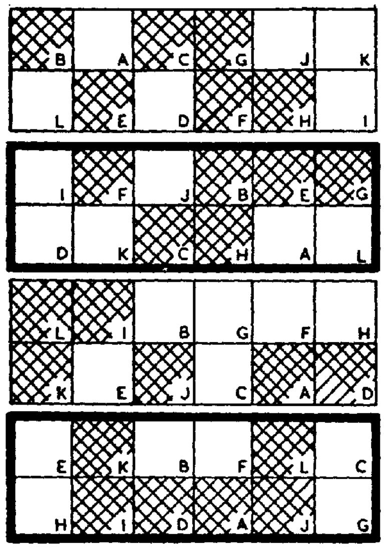

Fig. 1 : *Diagrammatic representation of one of the three blocks in Cooper's trial. Each square represents a plot, nominally of 100 bushes, raised from seed sources A to L. Cross-hatched plots received ammonium sulphate. Sub-blocks enclosed by heavy lines were under Sau trees. Distance between sub-blocks was 36 feet.*

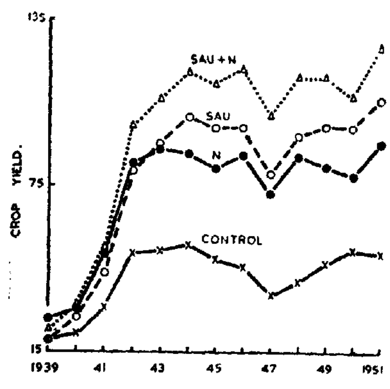

Fig. 2: *Cooper's trial. Yield from 1939 to 1951 in full sun and under Sau trees, both with and without nitrogen as ammonium sulphate. Each point is based on 3600 bushes. Scale shows pounds green weight per 36 bushes.*

and January, when the bushes are more or less dormant. Stems removed by pruning are equal to the weight of shoots removed for the manufacture of tea. Prunings normally lie on the soil and form a *mull* penetrated by tea roots. The annual addition of prunings to the soil is supposed to cause a circulation of nutrients in a form readily available to the tea bush. The dependence of tropical forest on a similar circulation of nutrients has been discussed by Pendleton[12]. Under our conditions the tea garden mull breaks down rapidly: much of it ceases to exist as mull by the end of the monsoon and becomes largely an addition of 'humus' to the soil. Some fixation of atmospheric nitrogen probably occurs in the mull.

At the end of 1951 the Sau trees were removed from two blocks of Cooper's trial and replaced by bamboo screens. This was done at the time of the annual prune. All the prunings were removed from the plots on this occasion, but not in subsequent years. All top parts of the Sau trees were removed but not the roots. These alterations, in conjunction with the statistical confounding of manure and shade (Fig. 1) resulted in eight new treatments being imposed on sets of 12 plots (*series* in Table 4) representing so many disparate populations (*jats*). Thus a set of 12 plots manured with ammonium sulphate and a similar set manured with superphosphate, occurred both under screens and Sau trees: other sets in full sun received either ammonium sulphate or superphosphate, the original control plots remaining unchanged. An adjacent field trial (experimental area No. 40) served as an additional control. The alterations are summarised in Table 4 which shows the yield before and after the change. Formal statistical analysis is not possible, but the number of bushes in each treatment is sufficiently large to permit useful conclusions. It is intended to discuss shade effects only, and leave the effect of fertilisers for a second article.

A striking feature of Table 4 is the big loss of yield in 1952. All the treatments showed a loss, even those that had not been altered. Bearing in mind the previous trend of yield (Fig. 2) the loss is surprising. However, it coincided with a falling trend in the additional control, as shown in Table 5; but comparison with

Table 4: Summary of changes in Cooper's trial. "N" signifies ammonium sulphate at the rate of 100 lbs. nitrogen per acre. "P" signifies superphosphate at the rate of 42 lbs. phosphorus per acre. Control is without symbol. Initial yield is the mean of the three years 1949-1951 in lbs. green weight per block. In each cell the upper value is absolute yield; the lower value gives the yield as a percent of initial yield.

Series (set)	1	2	3	4	5	6	7	8	9	10	11	12
New treatment	...		P		N		Screens		Screens with N	Screens with P	Sau trees with N	Sau trees with P
Old treatment	...	...	...	N	N	N	Sau	Sau	Sau + N	Sau + N	Sau + N	Sau
Block	1	3	2	3	1	2	1	3	1	3	2	2
Initial yield	1539	1782	1659	2602	2656	3115	3489	2826	3723	3636	4178	3602
Yield 1952	951 62	1098 62	1323 80	1378 53	1742 66	2159 69	2958 85	2362 84	3056 82	2790 77	2983 71	2727 76
,, 1953	745 48	634 36	945 57	1112 43	1345 51	2012 64	1954 56	1822 64	1920 52	2135 59	2750 66	2292 64
,, 1954	998 65	946 53	1286 78	1207 46	1432 54	2282 73	1953 56	1829 65	1889 51	2008 55	2708 65	2460 68
,, 1955	981 64	1036 58	1310 79	1350 52	1490 56	2442 78	2414 69	2322 82	2382 64	2434 67	3129 75	2931 81
,, 1956	1073 70	969 54	1483 89	1267 49	1639 62	2602 84	2614 75	2615 92	2621 70	2737 75	3413 82	3120 87

Table 4 shows that the losses in Cooper's trial were very much greater than those likely to be due to seasonal trend. We suppose these losses to be due to removal of prunings at the end of 1951. Cooper[5] had previously shown that removal of prunings reduced the yield of tea bushes even in the presence of fertilisers, but his observations were based on bushes growing in full sun. For various reasons Cooper's data are not directly comparable with ours, but they give no reason to suppose that the losses we record were not due to removal of prunings. It is of interest to note that Cooper thought prunings important for the provision of slowly available nitrogen.

Table 5: Yield of additional control (area No. 40) as a percent of its mean yield 1949-1951. Data for 360 bushes receiving 40 lbs. nitrogen as ammonium sulphate, compared with similar bushes from the same seed source ("F") growing in Cooper's trial.

	In full sun.		Under Sau trees.	
	Control-prunings not removed.	Cooper's trial: *prunings removed.*	Control: prunings not removed.	Cooper's trial: *prunings removed.*
Initial yield in lbs. green wt. per 100 bushes.	172	257	266	365
Percent yield 1952	88	60	95	71
" " 1953	81	54	95	62
" " 1954	114	61	95	58
" " 1955	123	63	106	72
" " 1956	117	67	108	73

The rate at which the new treatments permitted the bushes to return to normal yield can be shown by expressing yield as a percent of that obtaining before the prunings were removed (Table 4). We shall deal first with nitrogen and phosphate under screens and Sau, illustrated in Fig. 3. From 1954 onwards yield began to rise under screens and Sau, but Sau had been superior to screens in arresting the early loss of yield.

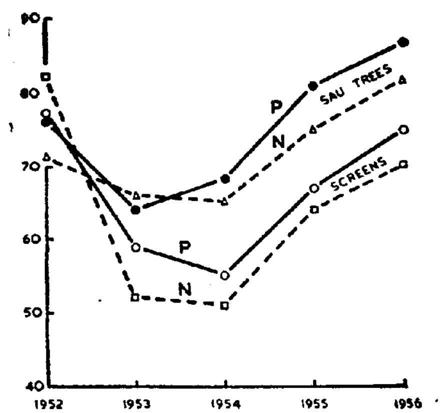

Fig. 3: Result of alterations in Cooper's trial made at the end of 1951. Ordinates show yield as percent mean yield for 1949—1951. The two upper curves are for Sau trees, the two lower for bamboo screens. Superphosphate treatment indicated by P, ammonium sulphate treatment by N. Each point based on 1200 bushes.

Many leguminous trees, including Sau, maintain a notably simple branch system. There is an annual succession of caducous stems which fall to the ground. The caducous stems are probably of more consequence than fallen leaves, and could account for much of the benefit of Sau, especially after the removal of tea prunings.

The differences between nitrogen and phosphate treatments in Fig. 3 will be dealt with in a second article. For present purposes we have replicated observations under Sau and screens, suggesting that Sau trees introduce desirable factors in addition to shade. However, the tremendous influence of shade alone (Table 1) cannot be overlooked.

Shade versus ammonium sulphate

The next observation of importance is the influence of shade versus sun on the rate of return to normal yield. Control plots in full sun showed a striking failure to regain their usual yield (Fig. 4). Yield continued to fall until tea prunings were

returned to the soil at the end of 1952 (1953 in Fig. 4) after which the yield began to rise: but it appeared to reach a maximum near the low level associated with the initial loss of prunings. On the contrary, those plots that had been placed under screens continued to return to normal yield.

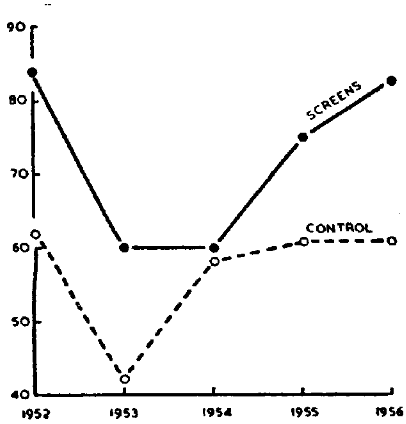

Fig. 4 : Alterations in Cooper's trial. Ordinates as Fig. 3. Rate of recovery under shade shown by upper curve, similar rate in sun by lower curve. Each point based on 2400 bushes.

Even when ammonium sulphate was applied to bushes in full sun their rate of yield increase did not equal that of unfertilised bushes under shade (Fig. 5). This suggests that factors other than nitrogen play an important part in the yield response ascribed to shade. It is to be remembered that Fig. 5 does not represent absolute yield, and the shade is on a soil the nature of which has been conditioned by the pre-existence of Sau trees.

Nevertheless, the fact that the increments obtained when screens replace Sau are relatively greater than the increments obtained from ammonium sulphate (Fig. 5) suggests that mere reduction of the light intensity on comparable populations growing in a suitable conditioned soil, might maintain a crop

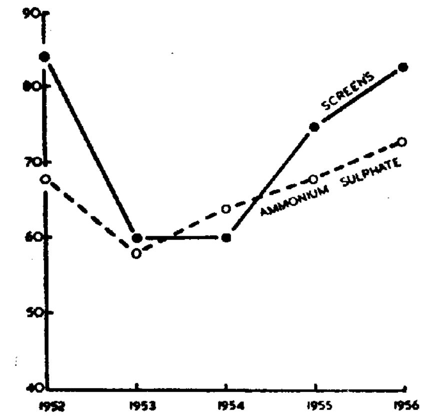

Fig. 5 : Alterations in Cooper's trial. Ordinates as Fig. 3. Rate of recovery under shade shown by upper curve, similar rate in sun in presence of ammonium sulphate shown by lower curve. Each point based on 2400 bushes.

yield as great as that supported by the alternative condition of an annual dose of 100 lbs. of readily available nitrogen.

Shade versus Sau

The immediate change in yield when screens replace Sau is of interest. When the change from the initial (1949-51) yield to the yield observed under Sau in 1952, is compared with the corresponding change to the yield observed under screens in 1952, then there appears to be a positive difference in favour of screens. For instance, the 'increase' in the presence of superphosphate (Table 4, cols. 10, 12) is—875 under Sau and —846 under screens, showing a gain of 29 pounds under screens. This is small and in the same direction as the initial difference: but in the nitrogen treatment (Table 4, cols. 9, 11) an increase under screens of 528 pounds has been sufficiently great to eliminate the initial difference. This effect of screens is summarised in Table 6. The yield of later years does not convey the same meaning because differences other than shade, such as tree droppings in the one instance and not in the other, become progressively greater and invalidate a comparison that,

in 1952, was approximately one between screen-shade and Sau-shade, other factors probably not differing very greatly. Cooper, in a private communication (1959) draws attention to the residual effect of Sau trees even when no compensation is made for the change of light intensity following their removal. This residual effect was found to persist for one year, but after that there was a sharp fall in yield[4]. It is possible that the removal of the Sau trees in our experiment might in itself account for some of the yield increment that we are ascribing to screen-shade; but it is also likely that the screens caused a more effective reduction of light intensity than Sau trees, and it is along this line of thought that the effects of screen-shade seem best interpreted.

Table 6 : Change in yield immediately following replacement of Sau trees by screens.

Year	Sau continuously (Series 11, 12, in Table 4).	Sau replaced by screens in 1952 (Series 9, 10).
1949 ...	3774	3645
1950 ...	3684	3420
1951 ...	4214	3974
Mean ...	3891	3680
1952 ...	2855	2923

The effect of shade is further illustrated by the data in cols. 7, 8 of Table 4. Here screens, without added nutrients, were placed over two sets of plots previously under Sau but with different yields. The plots with the lower yield when under Sau had the greater rate of increase under screens, leading to identical yields in 1956. This is probably because light intensity was more uniformly reduced by screens than by Sau, a Sau canopy being necessarily irregular and, in parts, non-existent.

A direct comparison of Sau with screens is possible for the year 1951 before the alterations in Cooper's trial. This

trial contains plots raised from the same seed source as the population in Table 1. In 1951 three of these plots were growing under Sau, without added nutrients. The percent increase in yield due to Sau is given in Table 7 along with the percent increase in yield due to screens (from Table 2). The difference between the mean yield due to Sau and the mean yield due to screens is not statistically significant. In one plot there seemed to be a loss of yield under Sau that might have been caused by unknown soil factors in the control having a greater effect than Sau trees; but the loss (—17) coincides with the most ill grown stand of Sau in Cooper's trial (Block 3) with large gaps in the Sau canopy probably associated with the absence of important Sau-factors other than shade. Thus it seems that the benefits of Sau additional to shade, if any, may be realised only under the canopy of the tree.

Table 7 : Comparison between 1951 yield of population "J" under screens and under Sau trees. Four blocks of the former and three of the latter : yields as percent increase over block controls.

	Bamboo screens.	Sau trees
	25	81
	58	67
	53	—17
	100	
Mean	59	43

Sau is supposed to typify a class of trees, as yet undefined, with similar effects on the yield of the tea bush. Some of the benefits of these trees, which we suppose additional to shade, might be realised in canopy gaps, were woody stems to be cut from special trees and used as a mulch, as is customary in southern, but not in northern, India.

It is possible that the benefit of shade may be realised only in the presence of appropriate soil factors. On a suitable

patch of soil it seems possible for yield under screens to be higher than yield under Sau (Table 7) but in general, yield under Sau on our soil seems better than yield under screens—at least for the populations investigated, and supposing the Sau canopy to be properly developed.

It seems evident that a superiority of Sau over shade would be conditioned by soil and fertilisers, and probably also by the genetics of the tea population. In a state of nature, soil suitable for the growth of shaded tea possibly necessitates the presence of certain trees of which Sau is an example: theoretical as well as practical interest therefore attaches to the possibility of differential yield among morphologically distinct tea populations growing under a Sau canopy.

Differential yield under Sau

The value of Sau relative to the value of shade, when different populations are considered, will be discussed in a later article. Here attention is confined to Sau and to the observation that the yield of tea bushes growing under Sau is related to the pubescence of the tea leaf.

In 1952 representative samples of leaves were drawn from the twelve populations in the control plots in Cooper's trial (full sun with no fertiliser). Pubescence was estimated subjectively, each leaf being placed in one or other of five groups to which the numerical values 0 to 4 had been given in ascending order of pubescence: group means, multiplied by 100, gave the pubescence scale in Fig. 6. In the same figure the ordinates give the mean annual yield of the populations grown in the presence of ammonium sulphate under a canopy of Sau trees, calculated from the yields recorded over the ten years 1941—1950. The correlation coefficient is 0.83 ($P < .001$). Inclusion of other years would not give a materially different picture, the period 1941—1950 being used merely because the data for those years happened to be conveniently summarised at the time of writing this section.

The relation in Fig. 6 is important because seedlings are usually selected for pubescence in nurseries exposed to full sunlight, the selection being intended to improve quality[19]. This selection for pubescence also selects a yield that is realised

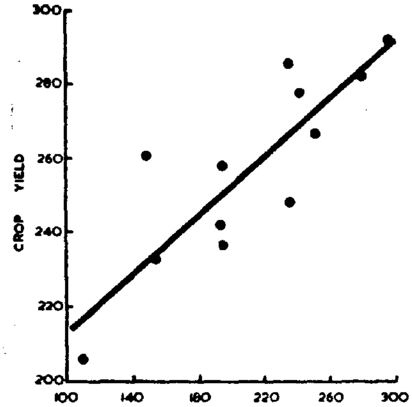

Fig. 6 : *Relation between development of pubescence in full sun without fertiliser and yield obtained when the bushes are grown under Sau and manured with ammonium sulphate. Yield as lbs. green weight per 100 bushes. Pubescence as mean ordinal values of subjective groups multiplied by 100.*

in the joint presence of Sau and ammonium sulphate. Further investigations, which need not be recounted here, suggest that the potential yield associated with pubescence is considerably more dependent on ammonium sulphate than on Sau. Thus some refinements of selection technique might be desirable were greater value to be attached to the yield increments possible under Sau and less to those caused by ammonium sulphate.

Table 8: *Quality of tea made from bushes of upper and lower grade pubescence when grown in shade and in sun. Pubescence determined in sun without fertiliser: quality with ammonium sulphate as fertiliser. Magnitude of quality derived from ordinal values of classes of taster's report, averaged for all populations in the pubescence class. Data, courtesy S. K. Dutta, based on Cooper's trial.*

Range of pubescence.	Number of populations (*jats*).	Mean quality in sun.	Mean quality under screens.
100—199	6	202	205
200—299	4	257	279

The relation in Fig. 6 refers to progenies of inter-breeding, mass selected populations. A much looser, possibly insignificant, relation is likely between the pubescence of populations obtained by line breeding or from a restricted number of clones, and their yield under shade-trees. However, it is important to note that the mass selection now practised in north-eastern India tends to maintain populations adapted to the traditional mode of cultivation in that region. Table 8 shows that the selected quality is unlikely to be adversely influenced by mere reduction of light intensity.

Discussion

From the data in Table 2 it follows that shade causes an increased removal of nitrogen (and other nutrients) from the soil in the form of crop yield. Bushes in full sunlight remove a lesser amount of nitrogen. This is relevant to the phenomena in Fig. 4 which could be explained by analogy with a bank account. It seems as if the loss of one year's prunings, which are supposed to represent nutrients in circulation, brought the currently available nutrients to a low level. More were put into circulation with the next lot of prunings, but this exhausted the current account. There is, in addition, a deposit account not available to bushes in full sun. Bushes in shade can draw on it (Table 2) hence the better return to normal yield under bamboo screens. A 'deposit' of nitrogen in the soil under monsoon conditions is likely to be difficultly soluble and could be in the form of lignin compounds, making woody matter such as tea prunings and shade tree litter not only helpful, but essential for the maintenance of yield under shade.

The increased yield and top growth of shaded tea bushes must be in some way reflected in the activity of the roots, leading to increases, and possibly alterations, in the nutrients removed from the soil. Tea being a mycorrhizal plant[15], the part played by its mycorrhizae in nutrient intake is also likely to be modified by changes in light intensity. In this connection it is to be noted that Björkman[1] found light intensity a determining factor in the formation of *Pinus* and *Picea* mycorrhizae. Thus it is suggested that certain nutrients become more available to the tea plant through its mycorrhizae and the fungal symbiont,

as the light intensity is reduced: nitrogen has been mentioned. A possible source of these nutrients could be the lignoproteinates said by Wilde[20] to be important in the mycorrhizal conditioned nutrition of woody plants in America. Tea mycorrhizae probably satisfy the general conditions indicated by Russell[14] who says "the mycorrhizal association appears to be the mechanism through which either phosphates from relatively unavailable forms, or nitrogen from organic compounds, are transferred from the soil to the tree". Furthermore, the possibility of some organic compounds being taken up directly by tea growing under shade, should not be overlooked.

Summary

Reduction of illumination intensity (shade) can greatly increase the yield of the Assam variety of tea (*Camellia sinensis* var. *assamica*). Nitrogen and other nutrients necessitated by this increased shade-yield are likely to be got from difficultly soluble organic compounds, and lignoproteinates are suggested. Illumination might condition an uptake of nutrients by fungal symbionts and mycorrhizae. Leaving aside this hypothesis, there is experimental evidence to show that tea prunings, consisting mainly of woody stems, are a necessary addition to the soil; but it seems that the value of shade can be enhanced by some factors introduced by Sau trees (*Albizzia chinensis*) or other comparable trees, that may be lacking when tea bushes and tea prunings alone are present. Attention is drawn to the caducous stems of Sau. Pubescence of a tea population, which is genetically controlled, is related to the yield obtained under a Sau canopy, particularly in the presence of ammonium sulphate. Proper replication of shade and Sau trees was not possible, but the use of very large numbers of tea bushes made it difficult to ascribe the observations to error.

The author's observations ceased at the end of 1956. In 1957 a storm damaged some of the Sau trees and caused large parts of the bamboo screens to be missing for several weeks. There was a sharp fall in yield below screens and trees, and so many unknown factors were introduced that the present discussion has been based on data for the period 1952-56. The

Sau trees in Cooper's trial did not live as long as anticipated. After the alterations the best trees remained, but they had been interplanted in October 1950 with *Albizzia odoratissima* saplings which grew exceedingly slowly. It does not seem likely that these saplings had much influence on the yield of tea until 1957, when large gaps in the Sau canopy became associated with irregular growth of *A. odoratissima.* Shade-tree effects have been ascribed to Sau (*A. chinensis*) partly for convenience in writing and partly because the influence of Sau was probably greater than the influence of *A. odoratissima.*

The author is indebted to Mr. H. R. Cooper for establishing, and to Dr. F. Yates for designing, the trial on which our observations are based: to Dr. E. K. Woodford for suggesting fundamental lines of enquiry: to Mr. S. K. Dutta, Senior Agriculturist, and Mr. L. K. Hatibarooah, Manager of our Experimental Estate, for recording the data from Cooper's and other trials: to Mr. P. K. Barua for estimates of pubescence, and Mr. L. R. Saikiah for practically the whole of the statistical work : and last, but not least, I am indebted to Dr. D. N. Barua, Plant Physiologist, and Mr. H. Ferguson, Director of Tocklai, for helpful criticism of the manuscripts of this and the following two articles.

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THE SHADE-TREE TRADITION IN TEA GARDENS OF NORTHERN INDIA :

II—THE USE OF AMMONIUM SULPHATE

BY W. WIGHT.

The first article suggested that tea bushes (*Camellia sinensis* L.) utilise natural sources of nitrogen more readily under shade than in the sun. Part II deals with ammonium sulphate under shade and under Sau trees and leads to the conclusion that the yield of many tea populations cannot be greatly increased by that fertiliser when the bushes cover the ground efficiently under an efficient shade-tree canopy. In Part I it was suggested that the shade given by bamboo screens might be as good as or better than the shade given by Sau trees, depending on the continuity of the Sau (*Albizzia chinensis*) canopy: the argument is resumed from that point with reference to the tables and diagrams in Part I.

Canopy continuity

The screens used in the experiments gave shade similar to that under a Sau tree. The screens were continuous, but in a stand of Sau the canopy is not continuous—even when the trees seem to touch, tea bushes farthest from a tree get almost full sun for some time each day: moreover, that is the condition at maturity, before and after which the canopy is more discontinuous.

Canopy inequalities were investigated at Tocklai by Mr. S. K. Dutta (unpublished) whose early work is quoted with permission. Observations were taken in a regular pattern of equidistant stations within a stand of Sau trees. Light intensity at the surface of the tea bushes was measured by a photo-electric meter set at a constant angle and distance from a standard reflecting surface. Dutta found that the yield of the tea bushes at the various stations could be expressed as a function of light intensity (Fig. 1).

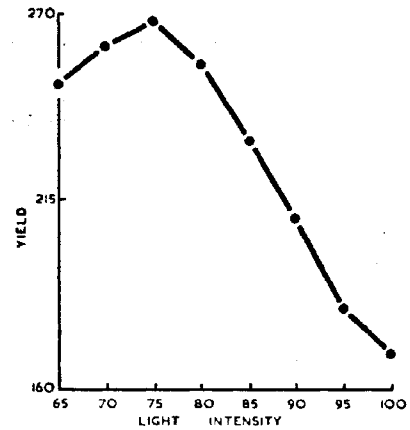

Fig. 1 : Absolute yield of var. assamica tea bushes receiving various light intensities when growing under Sau trees. Light intensity expressed as percent full sunlight. Yield expressed as lbs. green weight per 100 bushes. Bushes planted 1940 in 4.5 ft. triangular spacing. Seven rows of shade trees in each block planted at different spacings, ranging from 2 to 8 bushes apart i.e. 9 to 36 ft. apart within a row. Data courtesy S. K. Dutta, for area 2A.1 Borbhetta, 1951.

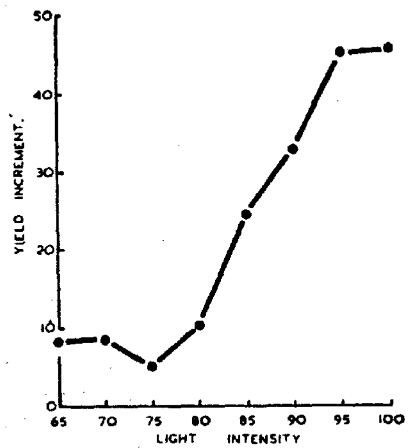

Fig. 2 : Percent increase in yield of tea bushes in Fig. 1 due to inorganic NPK fertiliser supplying nitrogen at the rate of 80 lbs. per acre.

These observations were repeated in two similar blocks receiving 80 lbs. of nitrogen as ammonium sulphate. Statistical analysis showed an interaction of fertiliser and illumination at the 5% level of significance. The percent increases of yield associated with the fertiliser are plotted against light intensity in Fig. 2 showing that an appreciable part of the fertiliser effect must be ascribed to *absence of shade*. As might be expected, Dutta's results showed, in general, that the highest light intensity is mid-way between the trees, and shade progressively increases with proximity to the tree. The tea bushes were 11 years old, in excellent condition, set four feet apart and capable of considerable increase in diameter. The population was raised from a source widely used in north-east India, nominally referable to var. *assamica*. At shade densities giving maximum yield the fertiliser did not cause a yield increase greater than 10% in the year of observation.

In Dutta's work nitrogen was applied in an NPK mixture at a rate of 80 lbs. nitrogen and 40 lbs. of phosphate and potash per acre. These nutrients are not without effect, but it will be shown in Part III that had nitrogen alone been used, differences greater than those observed by Dutta, and in the same direction, could have been expected. Thus it can be concluded that many tea bushes nominally 'under' Sau grow in an illumination intensity (shade) that is not optimum, however that condition may be defined.

Ammonium sulphate under shade

By shade is meant a reduced illumination intensity, obtained by the use of bamboo screens. Following the alterations in Cooper's trial, described in Part I, the rates of return to normal yield with ammonium sulphate as fertiliser, under shade and under Sau, were those shown in Fig. 3.

The rate of return to normal yield was greater under Sau than under screens—a finding difficult to align with traditional belief that the diminished return from ammonium sulphate in the shade of a Sau tree is because so much nitrogen is already supplied by the tree that the fertiliser cannot have much effect.

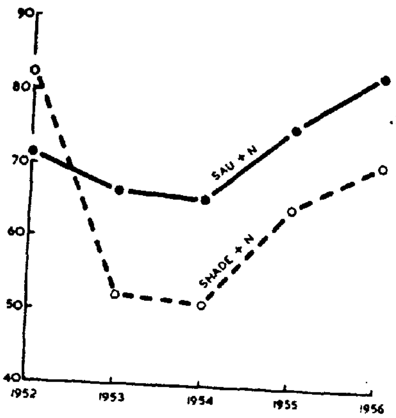

Fig. 3 : Results of alterations in Cooper's trial made at the end of 1951. Ordinates show yield as percent mean yield for 1949-1951. The upper curve is for Sau trees and the lower for bamboo screens, both in the presence of ammonium sulphate at the rate of 100 lbs. nitrogen per acre. Each point based on 1,200 bushes.

Contrary to this belief, ammonium sulphate is seemingly of greater value among Sau trees than under shade (Fig. 3). The operative word is *shade* : all the ammonium sulphate used among Sau trees is not used under shade, however that term may be defined.

In our experiments ammonium sulphate under shade greatly reduced the yield-rate (Fig 4) and caused an absolute loss of yield (Part 1, Table 4, cols. 7, 8, 9). The same shade by itself caused an increase of yield (Part I, Table 2).

Comparison of these results with Dutta's observations on canopy continuity, leads to the conclusion that yield increases under Sau, obtained by the use of ammonium sulphate, are largely due to the inefficiency of Sau as a canopy. The greater part of such yield increases are probably confined to bushes receiving illumination sufficiently intense to make ammonium sulphate necessary for the attainment of the yield that could have been expected under proper shade.

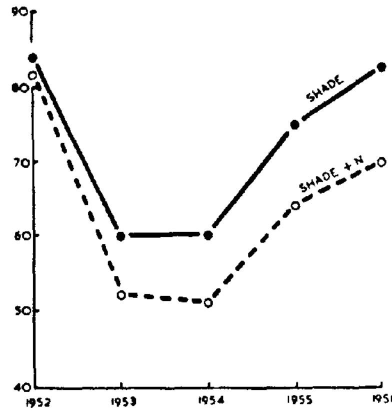

Fig. 4 : Alterations in Cooper's trial. Ordinates as Fig. 3. Upper curve for bamboo screens alone, lower curve for similar screens in the presence of ammonium sulphate at the rate of 100 lbs. nitrogen per acre. Top curve based on 2,400 bushes. Bottom curve based on 1,200 bushes.

These findings focus attention on Cooper's prediction that ammonium sulphate would be almost without effect under Sau (Part 1, Table 1). While the populations used by Cooper are distributed over the range of populations cultivated within var *assamica*, they do not represent the relative frequency with which the populations occur in cultivation: furthermore, the populations differ significantly in the mean area of a bush and thus in the efficiency with which the bushes cover the ground, and this has an important bearing on the interpretation of the trial, as will be shown in the next section.

The effect of bush area

In previous sections "yield" has been the yield of an average bush (*vide*. Part 1, Table 3) computed from equidistantly spaced bushes raised from numerous seed sources (*jats*). The surface area of a bush is conditioned genetically[8] and also physically when the bushes become sufficiently large to touch each other. Thus if one is to arrive at useful conclusions it is necessary to consider the yield of the real bush surface: this we call *real yield*. The effect of treatment on bush area and real

yield is shown in Table 1, supported by analyses of variance in Table 2.

Table 1 : Yield and bush area due to ammonium sulphate and Sau relative to control in full sun with no fertiliser. The control is made equal to 100 in each case. Yield per bush in lbs. per year is measured over 10 years from 1942 to 1951. Yield per unit area in lbs. per year is computed from the total yield of 3 years from 1949 to 1951. Bush area was estimated at the end of 1951.

	Sau	Sun	
Ammonium sulphate	236	178	Yield per bush. Ammonium sulphate and Sau with similar effect but not simply additive.
No fertiliser	198	100	
Ammonium sulphate	144	113	Yield per unit area. Ammonium sulphate with much less effect than Sau but the two simply additive.
No fertiliser	133	100	
Ammonium sulphate	155	147	Bush area. Ammonium sulphate and Sau with similar effect but not simply additive.
No fertiliser	144	100	

Table 2 : Analysis of variance of bush area and yield per unit area of bush surface, the latter computed from the total yield of three years 1949 to 1951, and bush area at the end of 1951. Columns give "F" values greater than unity. One asterisk indicates significance at 0.05 level, two at 0.01 level, and three at 0.001 level.

Source.	D.F.	Area.	Yield per unit area.
Replicates	2	...	1.50
J × N	3		
Sau (S)	1	37.54**	20.15**
J × S × N	3	...	...
Error	2		
Sub blocks	11	18.00***	18.88***
Ammonium sulphate (N)	1	171.05***	17.73***
Seed Source (J)	11	7.95***	4.45***
S × N	1	60.69***	...
J × S	11	...	1.33
J × N	11	...	...
J × S × N	11	1.05	1.09
Error	86	...	...

In practice it has come about that the usual spacing of tea bushes is such that the most commonly cultivated populations completely cover the ground about 10 years after planting. Thus a useful practical interpretation of Cooper's trial would be based on the real yield of a unit area of bush surface; and on that basis Table 1 shows that *Sau causes more than twice the yield increment got from 80 lbs. of nitrogen as ammonium sulphate.*

Table 1 also suggests that the whole of the increment got from ammonium sulphate in sun, when the bushes cover the ground, might also be got under Sau, at least within the limits of our observations. This could most easily be aligned with the depressing effect of ammonium sulphate in shade (screens) discussed in the previous section, by supposing that Sau provides something which makes ammonium sulphate effective under shade, and this would agree with observations described in Part I.

In Cooper's trial the mean increment under Sau trees, due to ammonium sulphate, was of the order of 38 lbs. on 198 lbs. or 19% (Table 1). Were the bushes spaced so that they could cover the ground, one might suppose the yield increments to be of the order of 11 lbs. on 133 lbs. or 8%. The increment expected by Cooper (Part I, Table 1) was 1 maund on 12 maunds, or 8%, showing that Cooper was aware of the real and rather small return to be expected from ammonium sulphate under Sau—in fact, he emphasised this in a handbook[3] on the economical use of fertilisers; but Cooper erred in supposing that the dose of ammonium sulphate used in his trial might be found more effective than Sau trees[2]. Subsequent results (Part 1, Table 1) suggested Sau to be about as good as 400 lbs. of ammonium sulphate per acre per annum; but more detailed analysis now suggests this much ammonium sulphate is not half as effective as a stand Sau trees in terms of the yield of real bush surface of mature tea.

The data (Table 1) show that ammonium sulphate acts mainly on bush frame, while ammonium sulphate under Sau trees does not greatly increase the yield of a unit-area of bush surface. Tea populations differ, some causing ammonium

sulphate to be more efficient and some causing it to be less efficient, and these possibilities will be discussed in a later section.

The conclusions reached here might sometimes seem at variance with the results of trials in tea estates; but there yield is expressed as the yield of a unit area of ground computed from the entire area and ignoring actual bush surface. For instance, when tea is planted in hedges under Sau with distinct pathways between the hedges, the bush frames can and do expand; and under those conditions ammonium sulphate gives a good return per acre of ground; but much of the ammonium sulphate might be discarded without loss of yield merely by rearranging the spacing of the same number of bushes so that the bushes could expand equally in all directions.

Probable nature of the interactions

The importance of *real yield*, or weight of plucked shoots obtained from a given area of bush surface, has been emphasised. Data from Cooper's trial failed to show a significant interaction between Sau and ammonium sulphate in terms of real yield, but this gives no reason for disbelieving the existence of a similar interaction between shade and ammonium sulphate. The large variance of the shade cast by Sau trees makes them unsuitable for demonstrating phenomena due to shade. What happens to real-yield under uniform illumination is an essential part of the information needed to explain what may or may not happen under a Sau tree. This problem has not been analysed statistically, but interactions of illumination intensity and ammonium sulphate, which are unlikely to be due to error, have been demonstrated. It is proposed to describe these interactions in some detail.

The yield was that of old bushes with well developed frames in close contact with each other (Tocklai, Area No. 1). They had been exposed to full sun for 30 years and during that time had been manured continuously with ammonium sulphate at the rate of 40 lbs. of nitrogen per acre per annum. Screens were erected over the bushes and the yield measured for one season only, this being a yield uninfluenced by changes in the

permanent bush-frame due to the new treatments, and necessarily being proportional to yield per unit area of bush surface. In this connection it is to be noted that our estimates of bush area are based on the frame of the bush after its top-hamper has been removed by pruning.

One plot of 300 bushes of the Assam variety was available for this experiment. It was divided into six smaller plots, nominally of 50 bushes, with a few unimportant gaps (vacancies) caused by earlier deaths. Three illumination intensities were established by screens, giving almost exactly 25%, 50% and 100% of full sunlight. Of the two plots under each intensity, one received no fertiliser in the year of the experiment and the other received ammonium sulphate at the rate of 150 lbs. nitrogen per acre. Six separate yields obtained in this way are recorded diagrammatically in Fig. 5. The original field data are given in Table 3.

Freehand curves are drawn in Fig. 5 to show the trends of yield with log. light-intensity. The uppermost curve represents yield in the absence of ammonium sulphate. At light intensity 1.0 (full sun) yield is taken as 100. On that basis yield at 0.70 light is 116 : at 0.50 light it is 108 : at 0.35 light, 100; and at 0.25 light, yield is 91. The three points marked by dots indicate observed yields, that in full sun being adjusted to 100 and the others in proportion.

The lowermost curve represents yield in the presence of ammonium sulphate at the rate of 150 lbs. of nitrogen per acre. At light intensity 1.0 yield is taken as 100: at 0.70 light, 83: at 0.50 light, 66: at 0.35 light, 61: and at 0.25 light, yield is 57. Three points marked by dots are based on observed yield adjusted as described.

Yield and nitrogen dosage are unlikely to deviate much from direct proportionality between the limits of 0 to 150 lbs. nitrogen per acre in full sun. If a similar approximation to linearity be supposed applicable to other light intensities, then a curve showing yield due to 75 lbs. nitrogen could have ordinates near to the means of the upper and lower curves. Making

yield in full sun again equal to 100, a freehand curve (the fourth from the top) was drawn through the points 100, 97, 88, 81, 74, corresponding with the five light intensities as before.

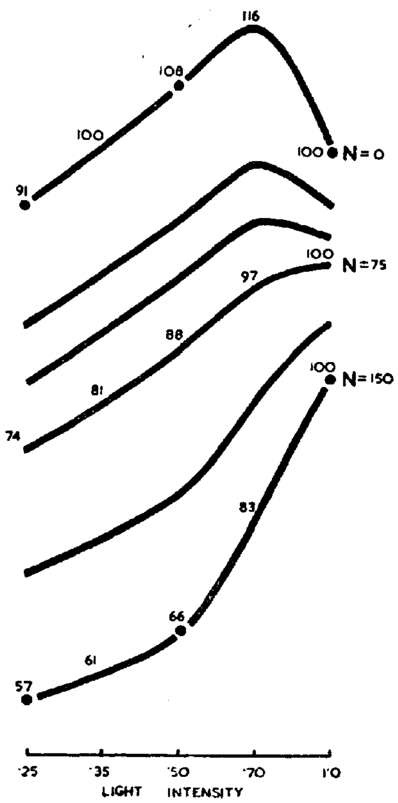

Fig. 5 : Curves representing the trend of hypothetical yield per unit area of bush surface, postulated for light intensities at various doses of nitrogen as ammonium sulphate, yield in full sun always being unity. Light intensity on logarithmic scale. A separate base is to be supposed for each curve. Six observed points indicated by solid dots.

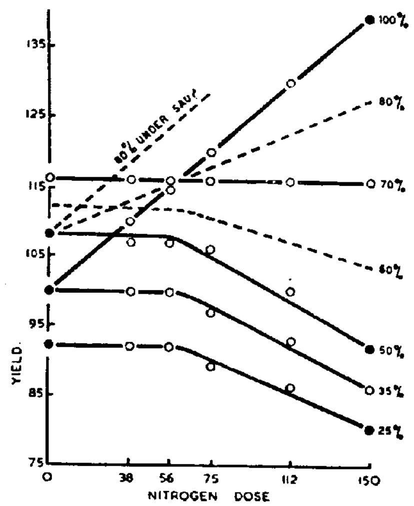

Fig. 6 : Hypothetical absolute yield associated with nitrogen dosage at various light intensities. The marked points are computed from the intercepts of the curves of Fig. 5 with light intensity (vide. Table 4). Six observed points indicated by solid dots.

It will be noticed that the curve for 75 lbs. nitrogen is almost linear. Using another, genetically distinct population, it was found possible, by adjusting nitrogen dosage, to get a linear regression of yield on the logarithm of the three light intensities 1.00, 0.50, and 0.25. Associated with the genetic difference was a nitrogen dose different from that under consideration (75 lbs.) but the direct observation of a linear regression gives some factual support for the mode of interpolation followed in Fig. 5. Six hypothetical curves were constructed for nitrogen doses 0, 38, 56, 75, 112, 150 lbs. per acre, numerical values for three curves being omitted from the diagram for the sake of clarity.

If the absolute yield observed in full sun with no nitrogen be taken as unity then the observed yield with 150 lbs. nitrogen in full sun would become 1.4 by proportion. Similarly, the relative absolute yield in full sun at 75 lbs. nitrogen would be 1.2 and so on. These adjusted absolute yields in sun are

given in Table 4 together with the percentages used in Fig. 5. The product of percentage and absolute yield gives the relative absolute yield plotted, in Fig. 6, against pounds of nitrogen.

While the data on which Fig. 6 is based can be criticised on statistical grounds, the major deductions do not seem very wide of the mark and are supported by numerous practical observations. The data were intended as a guide to more extended investigations, abandoned because of administrative changes at Tocklai.

Table 3 : Yield in 1948 of a var. assamica population (Stock 15, Tocklai area 3) manured with ammonium sulphate at the rate of 150 lbs. nitrogen per acre. Light intensity adjusted by screens to 50% and 25% of full sunlight (100%). Yield expressed as lbs. green weight per 100 bushes.

Percent light intensity.	No manure	Ammonium sulphate.
100	282	400
50	304	264
25	258	228

Table 4 : Hypothetical data derived from the freehand curves in Fig. 5 based on the primary data in Table 3. The second line gives the relative absolute yields to be associated with nitrogen (ammonium sulphate) in full sun : below that are given the hypothetical yields, for each light intensity and nitrogen dose, as a percent of yield in full sun. The product of percent yield and yield in full sun gives the ordinates used for the construction of the curves in Fig. 6.

Nitrogen dose in lbs. per acre	0	38	56	75	112	150
Yield in full sun	1·00	1·10	1.15	1.20	1.30	1.40
Percent yield at 1.00 light	100	100	100	100	100	100
,, ,, ,, .70 ,,	116	105.5	101	97	89	83
,, ,, ,, .50 ,,	108	97.5	93	88	77	66
,, ,, ,, .35 ,,	100	90.5	87	81	71	61
,, ,, ,, .25 ,,	91	83.5	80	74	66	57

The interactions in Figs. 5 and 6 suggest that conflicting results might be observed in practice by estate managers, because the yield of an average bush, irrespective of its area, often but by no means invariably, parallels its yield per unit of area. Thus, in Cooper's trial, no statistical correlation could be established, but if one of the 12 populations was deliberately excluded, then there appeared to be a correlation between yield per unit area of bush surface and yield of a mean bush. A similar statement could apply also to clones. Thus, from Fig. 6, shade differences between estates might sometimes cause nitrogen dosage on one estate to give yield data opposed to those obtained on another estate. Highly contradictory results have, in fact, been recorded. Ammonium sulphate has sometimes resulted in a more or less proportionate increase of yield up to doses of the order of 150 lbs. of nitrogen per acre. In other estates doses much above 80 lbs. have caused losses; and in some estates, nitrogen doses have been without effect under shade trees. All these results could be expected from the interactions in Fig. 6 *each one of which presupposes the others.* The system is determined by the inverse relation of the upper and lower curves in Fig. 5 and this agrees in principle with the inverse effects of nitrogen under high and low light intensities, recorded by White[6] in laboratory experiments with *Lemna*, discussed in Part I. That a similar system existed under Sau trees was clearly understood by Cooper[2] when he said "At some level of artificial nitrogen supply, we may expect no effect from shade trees. Under a certain density of leguminous shade we can expect no benefit from nitrogenous manures"; but it now appears that such systems are not necessarily dependent on the shade of a tree.

Genetic influences

Some details of an interaction between Sau trees and ammonium sulphate are shown in Fig. 7. This tea population has given similar results for 17 years. Fig. 8 shows an interaction between shade (bamboo screens) and ammonium sulphate. This population has given essentially similar results for seven years, in two of which there seemed to be a slight rising trend under shade, of doubtful significance.

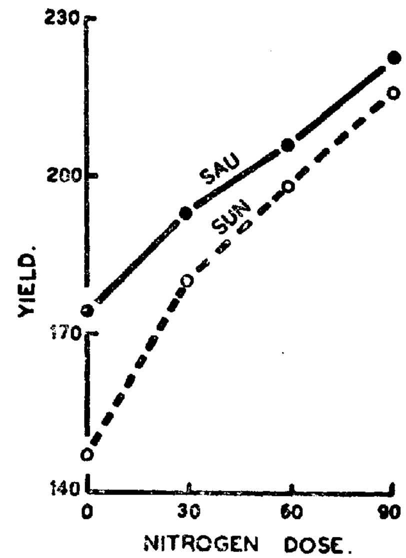

Fig. 7 : Interaction of ammonium sulphate and Sau trees in terms of the yield of a var. assamica population in Area 5 Borbhetta, 1949, based on four doses of ammonium sulphate giving pounds of nitrogen per acre shown by the abscissae. Bushes planted 1932 in 4 ft. square spacing with Sau trees planted 1942 spaced 32 × 36 feet. Yield expressed as lbs. green weight per 100 bushes.

The Sau canopy leading to the results in Fig. 7 was notably poor and although no proper data for light intensity exist, it is likely that many bushes received much more than 75% of the incident light. The slope of the curve for full sun, however, suggests that the population has an inherently poor response to nitrogen, and probably also to Sau trees, even when they are used efficiently. The example is important because the shade conditions are typical of those obtaining on many estates. Had the trial been conducted on an estate it might have been said to demonstrate an efficiency of ammonium sulphate "under shade." In this trial ammonium sulphate was used in conjunction with superphosphate and potassium sulphate, but it will

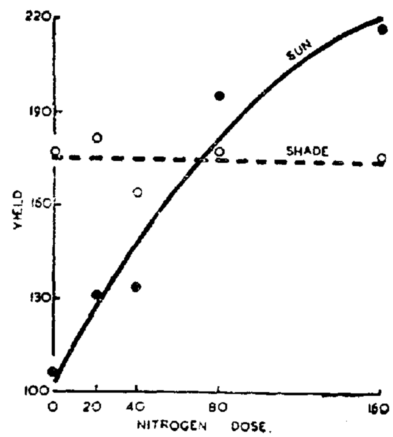

Fig. 8 : Interaction of ammonium sulphate and shade in terms of the yield of a var. assamica population in area 34, Borbhetta, based on five doses of ammonium sulphate giving lbs. nitrogen per acre shown by the abscissae. Ammonium sulphate was used in conjunction with superphosphate to give a constant N : P ratio of 1:0.9 or an $N:P_2O_5$ ratio of 1:2. Bushes planted in full sun in 1920 in 5 ft. triangular spacing. Shade imposed in 1951. Yield expressed as pounds green weight per 100 bushes. Shade given by bamboo screens, reducing the illumination intensity by 50%. Curves the computed best fit.

be shown in Part III that *lesser* yield increments could have been expected had ammonium sulphate alone been used.

In the other example (Fig. 8) ammonium sulphate is entirely without effect under 50% illumination intensity controlled by bamboo screens. This is important because the same screens on the same population have been shown to cause a yield increment of the order of 80% (Part I, Table 2): furthermore, this big increase was on bushes of above average yield in full sun.

Tree canopies are not often likely to shade the tea with the same efficiency as bamboo screens, and one might therefore expect the interaction of ammonium sulphate and Sau trees to be less pronounced than the interaction between ammonium sulphate and screens. The maintenance of a good canopy calls

for skilled management and naturally depends on conditions, but as good a canopy as that in Cooper's trial is possible in most tea estates. Hence the interaction between ammonium sulphate and Sau in Cooper's trial is of particular interest. It is illustrated in Fig. 9.

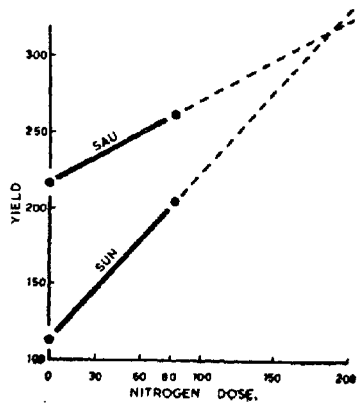

Fig. 9: Cooper's trial. Average interaction between ammonium sulphate (nitrogen) and Sau trees in terms of yield expressed as lbs. green weight per 100 bushes.

Table 5 : Comparative value of shade and ammonium sulphate on var. assamica and "China Hybrid" tea. Figures give yield as percent of that in full sun with no fertiliser. Control yield in lbs. green leaf per 100 bushes of the Assam variety was 282 lbs. and of the hybrid tea 268 lbs. "Shade" is an illumination intensity 50% of full sunlight. Ammonium sulphate at the rate of 150 lbs. nitrogen per acre.

	Assam variety		"China Hybrid"	
	Gain	Loss	Gain	Loss
Gain or loss due to shade ...	8	—	—	19
Same, due to joint effect of shade and ammonium sulphate ..	—	6	—	2
Gain or loss due to ammonium sulphate, with shade yield as base of reference ...	—	14	17	—

The examples, particularly Fig. 8, suggest that the interactions of Fig. 6 have some general validity. The interaction in Cooper's trial (Fig. 9) is the average of 12 populations and is a general case; but one must bear in mind that interactions between ammonium sulphate and shade might differ materially between sufficiently distinct populations. While the populations in Figs. 7 and 8 are both referable to var. *assamica* they can be recognised as distinct *agrotypes*[8] and this might somewhat invalidate the comparison of one with the other.

The model in Fig. 6 is not intended to apply to more than a limited range of agrotypes, and other interactions differing in magnitude, and sometimes in direction, might be needed for other ranges of agrotypes. For instance, the interaction illustrated in Table 5 was observed in a simple non-replicated experiment with the species-hybrid population described by Wight and Barua[7] as "China Hybrid." It is to be noted that this is not necessarily the China Hybrid of tea planters. The population is not referable to var. *assamica*, and its reactions to shade and nitrogen seem to be the opposite of that taxon. Shade caused a loss of yield that could be regained by the use of ammonium sulphate.

A real loss of yield under shade was confirmed by statistical analysis of the data for a high quality clone selected from a commonly cultivated population. This would be regarded as var. *assamica* by herbarium workers, but it is distinct from the wild form and almost certainly has a mixed ancestry. The light intensity on small plots (4 bushes) of this clone was reduced to 50% full sunlight by bamboo screens. Ammonium sulphate and urea were used, each at two levels of nitrogen. Pruning weight plus the weight of 8 initial pluckings were used to adjust the experimental yields by the method of covariance. The adjusted analysis of variance is given in Table 6 and a summary of the data in Table 7. There was a real loss of yield under shade that could be regained by the use of nitrogenous manure. Urea was much more efficient than ammonium sulphate. The "F" value of 2.8 associated with the second order interaction suggests that significance might be attained with better replication. This would mean that the tea plant utilised

a manure to an extent depending on the amount of nitrogen and also on the light intensity. Such a behaviour, if established, would be in line with the hypothesis in Part I where an increased utilisation of organic nitrogen under shade was suggested.

Table 6 : Analysis of variance of the 1951 yield of clone No. 20/17/5 adjusted on the basis of initial yield Ammonium sulphate and urea were used at the rate of 75 and 150 lbs. nitrogen per acre under 100% and 50% light intensities.

Source	D.F.	Mean square.	F	P
Block	1	206.72	8.41	<.05
Manures (versus check)	1	656.94	26.74	<.001
Kind of manure (M)	1	131.05	5.33	<.05
Level of nitrogen (N)	1	1.33	...	...
M × N	1	365.86	14.89	<.01
Treatments (in general)	4	288.80	11.75	<.01
Light (L)	1	378.10	15.39	<.01
L × (manures versus check)	1	1.39	...	...
L × M	1	43.13	1.76	...
L × N	1	0.48	...	...
L × M × N	1	69.93	2.85	...
L × (treatments)	4	28.73	1.17	...
Error	9	24.57	...	...

These observations imply that the interaction of ammonium sulphate and other nitrogenous manures, with shade and Sau, could be modified by agrotype: this should lead to a statistically significant second order interaction between agrotype (and jat), ammonium sulphate, and shade (and Sau); but the analysis of Cooper's trial (Part, Table 3) failed to show the significance of this interaction. It is however known that the introduction of a scale of agrotypes (rank order) into the analysis can lead

Table 7 : Summary of the adjusted yields of eight year old bushes of clone No. 20/17/5 showing the losses under shade. Yield expressed as lbs. green weight per 100 bushes. Pounds of nitrogen per acre indicated in parenthesis after the manure.

	Yield in the sun.	Percent loss in 50% light
With no manure	77.0	19.8
Ammonium sulphate (75 N)	86.6	14.3
Urea (75 N)	111.7	13.5
Ammonium sulphate (150 N)	106.6	22.9
Urea (150 N)	88.9	1.2

to a better appraisal of the influence of populations on the interaction between ammonium sulphate and Sau, but further consideration of this problem is beyond the scope of the present series of articles.

Discussion

Ammonium sulphate is used as a fertiliser in conjunction with shade-trees and in these circumstances it is commonly said to be used "under shade"; but its positive effect on the yield of tea bushes growing among Sau trees is appreciably dependent on some of the bushes not being shaded. The condition of the shade-trees in a sample survey of tea estates (Table 8) showed an unsatisfactory development of the tree-canopy that could be expected to make ammonium sulphate a profitable fertiliser and lead to those yield increases commonly alleged to demonstrate a need for ammonium sulphate "under shade": this term, unfortunately, is applied to any plantation in which trees are nominally present, and a more objective verbiage might lead to clearer thinking and a better appreciation of the experiments described in this article.

Table 8 : Condition of the shade-tree canopy in 14 estates in Tezpur, Assam, 1953. The survey unit is the section, an administrative unit within an estate, with an area of 20—30 acres.

	Number of sections.	Percent of whole
Shade-trees giving adequate shade and likely to do so for some years ...	136	30
Older trees, seemingly satisfactory, but not likely to remain so because of age and possible disease ...	118	25
Shade-trees nominally present, but shade almost valueless ...	211	45

The surface area of tea bushes differs between populations. When this is taken into account it is found that Sau trees cause more than twice the increment got from 80 pounds of nitrogen as ammonium sulphate (Table 1). Thus, with appropriate spacing of tea bushes, a canopy of Sau could probably be equivalent in yield response to 200 pounds of nitrogen as ammonium sulphate: this is far beyond the range of approximate linear response to ammonium sulphate and probably near the point at which yield would begin to be depressed (*vide* Barua[1]); and thus it seems that no nitrogen dosage could be better than Sau trees if proper attention be paid to spacing of the bushes and maintenance of the Sau canopy. Some nutrients beneficial to the yield of tea bushes are probably provided by Sau trees, and those nutrients may also be necessary for the existence of the Sau: thus *a major agronomic problem would appear to be the manuring of shade-trees and not the manuring of tea bushes*: for instance, molybdenum might be found necessary. Cooper[2] indicated the need for manuring shade trees, but, in our opinion, the fundamentals of this subject have not been investigated.

Ammonium sulphate seems to be without effect on the yield of tea bushes growing under optimum shade, in soil where some essential minimum of nitrogen was available at the beginning of the experiments. Possible interpretations of this condition will be discussed at the end of Part III. Given this condition,

then the manifest effect of ammonium sulphate "under" Sau depends much on gaps in the canopy; in addition, it seems that Sau causes ammonium sulphate to have a slight but real effect in the shade of the tree. If the surface area of a tea bush be considered, and arbitrarily established spaces between bushes be ignored, then yield increments due to Sau alone and increments due to ammonium sulphate used under Sau, seems to be directly additive, and the so-called interaction between ammonium sulphate and shade-trees, as exemplified by Sau, vanishes.

While nitrogen in sun (relative to Sau) has little effect on yield of bush surface, it has a great effect on area of the surface (Table 1): Sau has an equal effect; but the effects of nitrogen and Sau on area are not directly additive, and this interaction supervenes in the customary analysis of field trials where a constant number of tea bushes are grown in plots of constant size, and yield per plot analysed irrespective of bush area.

In practice it is necessary to take bush area into consideration, and this raises some problems: if the bushes have to increase in area merely to cover the ground, then this object could be achieved by modifying the spacing instead of relying on ammonium sulphate or Sau to increase the area of the bushes. It is necessary to know *when* the bushes are to cover the ground? If, by close spacing, they soon cover the ground then the bushes have small frames and the author's experience suggests that tea bushes unable to increase in diameter for some minimal period of, say, five to ten years, may have a reduced life span. It might be necessary to take account of this when deciding the date by which complete ground coverage is required. If the initial spacing were such that the bushes could cover the ground by the required date, whatever that might be, then ammonium sulphate would seem unnecessary provided that the initial condition of the soil permits necessary nutrients being put into circulation by the cultural system.

These considerations make it essential to know the effect of ammonium sulphate and shade *on the yield of bush surface* under the conditions of the experiments. The available observations lead to a set of hypothetical curves suggesting that there

is a density of shade giving a certain increase of yield of the bush surface that cannot be bettered by using ammonium sulphate under that shade; but lesser shade would give a lesser yield that could be increased by ammonium sulphate. The biggest return per pound of ammonium sulphate however, would be got by using large doses in full sun; but should fertiliser be discontinued, yield would drop to a level lower than that obtained under shade alone. Practical experience supports these interpretations.

Notably different results might be obtained by extending the range of genotypes: for instance, shade was observed to depress the yield of a "China Hybrid" population, ammonium sulphate being more than usually effective under the shade. It is possible that genetically related populations not necessarily looking like "China Hybrid", grow under shade trees in tea estates where they could wrongly demonstrate a need for ammonium sulphate. It is to be noted that "China Hybrid" is used in the sense of the species hybrids investigated by Wight and Barua[7] and Roberts, Wight and Wood[5].

Selection in north-east India has been directed towards shade-demanding forms of tea plant; but a bias towards sun-demanding forms seems equally possible and might lead to populations giving even larger yield increases per unit area of bush surface with ammonium sulphate in full sun, than is possible by growing the present populations under Sau trees. This needs detailed and separate consideration, but it can be noted that big increases with ammonium sulphate probably go with genetically low initial yield, and further evidence, not presented here, shows the possibility of forms with a yield so high that ammonium sulphate would have little effect, even in full sun.

These observations lead us to define shade-forms of tea as those in which the maximum yield under shade could be attained in sun only by increasing the supply of nitrogen or other nutrients; and sun-forms might be defined as those in which the maximum yield in sun could be attained under shade only by increasing the supply of nitrogen or other nutrients. In this connection it can be noted that Gast[4], working with

conifers, generally accepted as sun-demanding, found, in moderately high radiation intensities, that an increase in nitrogen availability could offset a deficiency in radiation. Gast also found that the intake of nitrogen varied with illumination intensity when *Pinus sylvestris* was grown in humus, but this important phenomenon was obscured in sand cultures with constant and comparatively large quantities of free ions. Gast supposed mycorrhizae important in natural conditions of growth in humus, and believed that nutrient intake by mycorrhizae might be influenced by illumination intensity acting *via.* the transfer of "food" from shoot to root. Similarly, it was suggested in Part I of the present series of articles, that an intake of nitrogen and other nutrients from lignoproteinates *via* mycorrhizae and fungal symbionts, might be increased under shade. The concept of sun-forms of tea, now introduced, calls for a greater intake in sun that would appear to be in line with Gast's observations.

Summary

In the present study, the yield of tea (*Camellia sinensis* L.) means the green weight of shoots plucked from a unit area of the surface of mature bushes. It is estimated that one thousand pounds of ammonium sulphate per acre of plantation causes yield increments of the order of 10-20%. Greater increments are possible without ammonium sulphate, merely by growing the tea under a canopy of Sau trees. When ammonium sulphate and Sau trees were used together in a field trial, then the yield increments appeared to be the sum of those due to the two factors separately. An interaction, in terms of yield as defined was not discernible under Sau trees.

Separate experiments under bamboo screens (shade) showed that a large part, but not all, of the yield under Sau could be ascribed to shade. Under screens, the joint effect of ammonium sulphate and shade was less than the sum of their separate effects. Comparison with the results obtained under Sau suggests that the trees do something to increase the efficiency of ammonium sulphate under shade. Greater efficiency might be attained by manuring the shade-trees instead of the tea bushes, but the nutrient requirements of shade-trees have not been properly investigated.

Ammonium sulphate has a very much greater effect on bush area than on yield: so has Sau. As evenly spaced bushes cannot increase in area when they touch each other, the time at which that condition should be attained determines the necessary spacing. The possible area of a bush differs between populations. In the present study the expression "mature bushes" means bushes that were unlikely to show an appreciable increase in area at the given spacing and the given age.

On soil containing a sufficient initial supply of nutrients there is an optimum density of shade giving an increase of yield that cannot be bettered by using ammonium sulphate under that shade; unless, possibly, the shade be provided by a Sau tree. Lesser shade would give a lesser yield that could be increased by ammonium sulphate. The biggest yield from ammonium sulphate is obtained in full sun.

Illumination under a set of Sau trees varies from optimum shade to full sun, and the yield increases due to ammonium sulphate at various positions under the Sau trees are positively dependent on illumination intensity—*i.e.* on absence of shade. This picture is for the shade-forms of tea usually grown in the plains of north-east India. Selection for sun-forms might make yield increases due to ammonium sulphate negatively dependent on illumination intensity.

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THE SHADE-TREE TRADITION IN TEA GARDENS OF NORTHERN INDIA :

III—SUPERPHOSPHATE AND LIGHT INTENSITY.

BY W. WIGHT

The first of these articles showed that shade is a factor of major importance introduced by the Sau tree (*Albizzia chinensis*) commonly used in tea gardens. Shade causes an increased yield of the tea bush (*Camellia sinensis*) which necessitates an increased nutrient intake likely to be from relatively insoluble organic sources: it was suggested that this intake might be *via.* symbiotic fungi. In Part II ammonium sulphate was shown to interact with Sau in respect of the size of tea bushes but less so in the yield of their surface. This third and last article shows that superphosphate might be a more important fertiliser than ammonium sulphate under Sau, and that it is possible to define tea populations which show an obligate dependence on Sau.

Superphosphate under shade

Superphosphate supplies calcium and phosphorus and small quantities of other nutrients. *As with all fertilisers, the yield under shade is essential for an understanding of the yield under Sau.* To study this problem, bamboo screens were erected in 1948 over bushes that had been exposed to full sun for 30 years (Tocklai Area I). During that time they had been manured continuously with ammonium sulphate at the rate of 40 lbs. of nitrogen per acre per annum. Under our conditions the bushes could be supposed starved of phosphorus and the soil somewhat depleted of calcium.

Two plots were screened to give 50% light and two plots were left exposed. The bushes were touching each other and incapable of expansion, but it was found in 1948 that screens alone, without ammonium sulphate, were associated with a

slightly increased yield (Part II, Fig. 5). In 1949 ammonium sulphate was applied to all plots at a rate of 225 lbs. nitrogen per acre, with the intention of raising the yield of the sun plots to a maximum (*vide Barua*[2]) and of depressing the shade yield: it had, in fact, been shown in 1948 that 150 lbs. nitrogen would depress the shade yield of these plots. One of the shaded and one of the unshaded plots was treated with superphosphate at the rate of 450 lbs. P_2O_5 per acre: thus the doses of nitrogen and phosphorus were more nearly equal than is usual 1.0 N : 0.9 P).

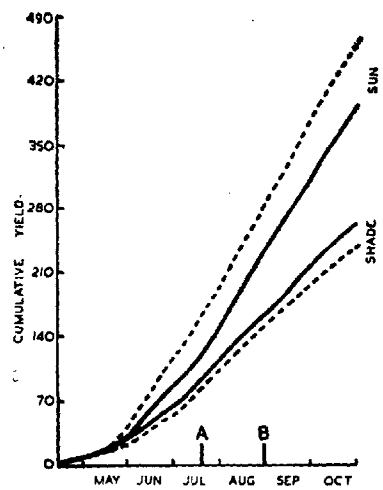

Fig. 1: Curves showing cumulative yield of var. assamica with and without superphosphate in sun and shade, both treatments in the presence of ammonium sulphate. The two upper curves are for sun and the two lower for shade, superphosphate being indicated by solid lines. Shade is approximately 50% of full sunlight. Ammonium sulphate at the rate of 225 lbs. nitrogen per acre; superphosphate at the rate of 196 lbs. phosphorus per acre. Yield as green weight in lbs. per 100 bushes.

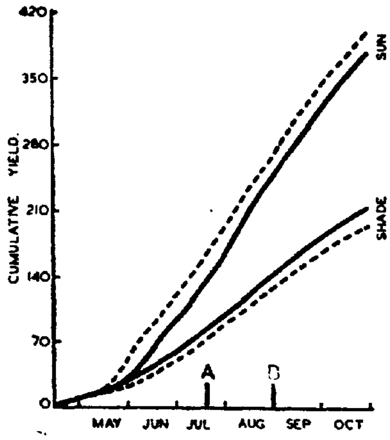

Fig. 2: Curves showing cumulative yield of "China Hybrid" tea with and without superphosphate in sun and shade, both treatments in the presence of ammonium sulphate. The two upper curves are for sun and the two lower for shade, superphosphate being indicated by solid lines. Shade is approximately 50% full sunlight. Ammonium sulphate at the rate of 225 lbs. nitrogen per acre; superphosphate at the rate of 196 lbs. phosphorus per acre. Yield as green weight in lbs. per 100 bushes.

As no replicates were possible, statistical analysis is out of the question. The trend of yield is illustrated in Fig. 1. Superphosphate was depressing in full sunlight but it is clear that an availability of some nutrients necessary under shade must have been improved by the presence of superphosphate.

The foregoing experiment used the Assam variety of tea plant. An adjacent, equal sized, plot of the bushes described by us as "China Hybrid", (*vide Part* II) had received identical treatment for thirty years and this plot was simultaneously subject to the same changes. Here also, the bushes had attained their maximum size. The results, shown in Fig. 2, were identical. It can be noted that superphosphate had a buffering effect on yield differences between light intensities.

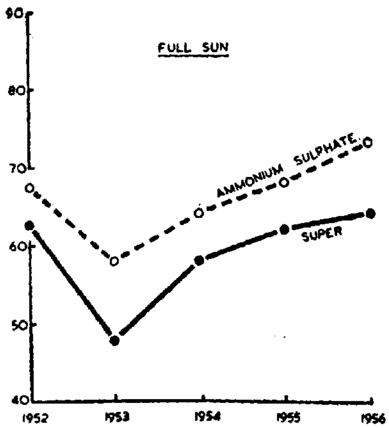

Fig. 3: Fertilisers in full sun. Data from Part I (Table 4). Ordinates show yield as percent mean yield for 1949-1951. The solid line is for superphosphate at the rate of 44 lbs. phosphorus per acre; the broken line for ammonium sulphate at the rate of 100 lbs. nitrogen per acre.

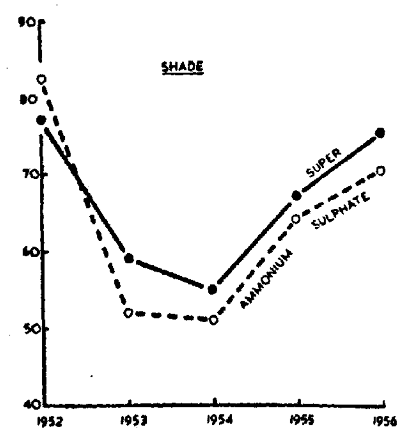

Fig. 4: Fertilisers in shade. Data from Part I (Table 4). Shade given by bamboo screens transmitting about 45% full sunlight. Ordinates and fertiliser doses as Fig. 3.

It was not practicable to continue the experiments for a second year, and while they might have become detrimental, pathological effects were not detected during the course of the experiment. A large dose of 'super' was needed to ensure moderate availability of phosphorus; and in this experiment the important point was not manurial practice, but the immediate effect of nutrients other than nitrogen on old bushes that could be supposed starved of such nutrients.

Following this experiment, the alterations in Cooper's trial made possible a comparison between ammonium sulphate and superphosphate used separately under screens and in the sun. The data, already recorded in Part I (Table 4) are shown graphically in Fig. 3 and 4. Shade (45% light) depressed yield in the presence of either fertiliser at the given dosage: nevertheless, it is clear that 'super' can be better than ammonium sulphate under reduced light intensity while the reverse is likely to hold in full sun.

Superphosphate under Sau

We pass now to superphosphate under Sau. The data, from Part I, Table 4, are illustrated in Fig. 5 and show that 'super' is better than ammonium sulphate in spite of the possible inefficiency of 'super' on the less well shaded bushes.

It is to be noted that 'super' under Sau caused a greater rate of recovery than 'super' under shade (Fig. 4 & 5) and this could not be ascribed to physical changes in the nature of the tree canopy considered as an illumination screen. Leguminous cover crops in general seem to be deficient of phosphorus on our soil, and superphosphate possibly caused an increased circulation of phosphorus and other elements, through the caducous stems and deciduous leaves of Sau, making the elements more readily available to the tea bush: in particular, organic phosphorus might be better utilised than inorganic phosphorus.

Superphosphate seems a better source of nutrients than ammonium sulphate under the canopy of Sau used in the experiment, but were the canopy more broken, then a contrary result might be expected. Several nutrients may be operative, but

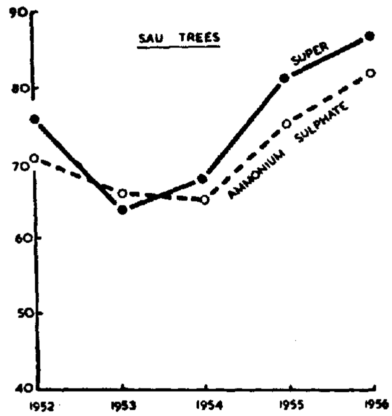

Fig. 5: Fertilisers under Sau trees. Data from Part I (Table 4). Ordinates and fertiliser doses as Fig. 3.

phosphorus suggests itself as one of importance. Its intake has often been associated with mycorrhizae, the possible significance of which was discussed in Part I.

Potassium under shade

Potassium is known to interact with light intensity in the growth of plants[11]. In the experiment illustrated in Figs. 1 and 2, potassium sulphate was applied to all plots at the rate of 225 lbs. K_2O per acre at the time marked "A" : later, at the time marked "B" the dosage was raised to 675 lbs. K_2O per acre. While no conclusions are possible, it is evident that there was not a marked interaction of potassium sulphate with light intensity in the presence of the other fertilisers. In this connection it is to be noted that the proportions of N:P:K were similar to those in the 'balanced' fertiliser introduced by the author[15] for use on young tea bushes before their frames fully cover the ground.

Further short term observations were made in September and October of 1950 on small plots (six bushes) within one population raised from one seed source. There were three

Table 1 : The effect of potassium sulphate on the yield per unit area of tea bush in September and October, 1950. Yield expressed as lbs. green weight per 100 bushes for the eight pluckings on which the observations are based. Ammonium sulphate (N) at the rate of 225 lbs. nitrogen per acre; potassium sulphate (K) at the rate of 187 lbs. potassium per acre; and the joint treatment as the sum of the two doses. Shade given by bamboo screens transmitting approximately 33% full sunlight. Observations based on six bushes per treatment per block. Tocklai, Area II.

	Shade				Sun			
	Blocks			Total	Blocks			Total
	1	2	3		1	2	3	
N	137.5	100.0	100.0	337.5	150.0	175.0	131.2	456.2
K	75.0	62.5	87.5	225.0	106.2	62.5	175.0	343.7
NK	100.0	87.5	125.0	312.5	175.0	137.5	150.0	462.5

Table 2: Effect of ammonium sulphate alone and ammonium sulphate plus potassium sulphate on yield of bushes growing in full sun and plucked at various heights. Yield for 4 disparate jat populations (stocks) as lbs. green weight per 100 bushes. Ammonium sulphate (N) at the rate of 256 lbs. nitrogen per acre. Potassium sulphate (K) at the rate of 106 lbs. potassium per acre. Tocklai, Area II.

Height of plucking in inches.	Stock 16		Stock 2		Stock 3		Stock 18		Relative total.	
	N	NK	N	NK	N	NK	N	NK	N	NK
4	503	442	467	451	609	487	552	458	100	86
6	510	479	436	418	494	379	468	440	90	80
8	464	481	484	395	508	475	514	356	92	80
10	472	453	458	350	444	407	457	384	86	75
12	434	427	331	366	544	321	457	373	83	70
14	376	361	317	345	407	314	426	354	72	64
Mean	459	440	415	388	501	397	479	394	87	75

repeats in sun and three under screens (33% light). Yields are given in Table 1 which fails to show any tangible effect of potassium sulphate except that it was depressing when used by itself. The results, though brief, are sufficient to show that possible interactions of potassium sulphate with illumination do not occur with any rapidity and are unlikely to be as pronounced as those between superphosphate and illumination. Potassium sulphate seems to have a depressing effect on the immediate yield of the plucked surface of the bush, either in full sun or under shade. The depressing effect in full sun is well known and is further illustrated by data in Table 2 which suggest an interaction of potassium sulphate with the genetic factors of disparate populations.

Because of its necessity for the woody frame of the bush[18], potassium must be supposed important in any concept of yield that depends on bush size; but maximum size being attained it would seem that potassium sulphate is less necessary than superphosphate, especially under shade conditions. No useful comparisons between potassium sulphate under shade and under Sau were available at the time of writing.

Calcium nitrate and other manures

Individual tea plants, clones, and populations, are characterised by specific deposits of calcium oxalate crystals. A genetically determined scale giving the relative position of both individuals and populations can be made on the basis of these crystals [16]. The crystals are indicative of a K/P ratio in the plant and they have been associated with the number of plucked shoots[13]. Unpublished work on clones shows that shade can either increase or diminish the number of crystals, depending on the clone. One might suppose, therefore, as did Bamber[1], that calcium, particularly that added to the top-soil as litter from a shade-tree. canopy, is a significant factor in the nutrition of the tea bush.

There is some evidence that the efficiency of calcium supplied as fertiliser might be influenced by light intensity. Table 3 shows 150 lbs. of nitrogen as ammonium sulphate to be depressing at low light intensity, whereas the same dose of

nitrogen as calcium nitrate seemed to have a positive effect on yield : but the gross yield due to calcium nitrate was less than that due to ammonium sulphate. In interpreting trials of this nature some account should be taken of the calcium content of the tea plant. In respect of yield it may be important to express total calcium relative to that fraction which is defined by the calcium oxalate crystals in the leaf petiole[17]. On this relative basis there might be a 'luxury' intake of calcium leading to an imbalance of nutrients which could cause nitrogen to have a diminished efficiency in terms of yield; but under other conditions a deficit of calcium might have to be visualised. In Table 3 differences between ammonium sulphate and calcium nitrate might be ascribed to ammonium nitrogen versus nitrate nitrogen, but they also seem sufficiently in line with the differences between ammonium sulphate and superphosphate to suggest that calcium might play some part in the interaction of light with fertilisers.

Table 3: Yield of plucked shoots of the wild form of var. assamica in 1953. Yields adjusted by covariance on the basis of initial yield. The upper half of the table gives the yields for four manures used at the rate of 75 lbs. nitrogen per acre. The lower half of the table gives the yields for the same manures when each is used at the rate of 150 lbs. nitrogen. The observed effect of shade is shown as percent gain or loss over the yield in the sun.

Yield in the sun.		Percent gain	
		75% light	50% light
Ammonium sulphate (75 N)	127	22	7
Oil cake	122	11	6
Calcium nitrate	124	11	−2
Urea	103	42	25
Ammonium sulphate (150 N)	164	−3	−13
Oil cake	154	5	−2
Calcium nitrate	127	15	14
Urea	129	15	7

Table 4: *Analysis of variance of the 1953 yield of a wild type var. assamica population (Area 8, Borbhetta) adjusted on the basis of the first four pluckings in 1952 before the initial application of manures. Ammonium sulphate, calcium nitrate, urea and oil-cake, were used at the rates of 75 and 150 lbs. nitrogen per acre under 100%, 75% and 50% light intensity.*

Source.	D.F.	Mean square	F	P
Block (B)	3	2.784	...	...
Light (L)	2	70.764	2.03	...
Error (B × L)	6	34.802	...	...
Total	11	...	...	...
Manure (M)	3	75.560	5.03	<.01
Nitrogen level (N)	1	355.757	23.69	<.001
M × N	3	15.556	1.03	...
L × M	6	15.343	1.02	...
L × N	2	25.034	1.66	...
L × M × N	6	13.997	...	...
Error	63	15.014	...	...

The data in Table 3 are derived from a field trial in which differences of light intensity were always in the presence of nitrogenous manures. No plots were without manure. The population was the wild type of var. *assamica*, of considerable technical interest but very rarely found in cultivation. The light intensity was permanently controlled by screens. The screens, however, were erected several weeks in advance of the first (annual) application of manures. The effect of light intensity, without manures, is distinctly different from that to be expected in the presence of the large amounts of nitrogenous manure in this trial. It was possible to use the method of covariance to adjust the subsequent yields on the basis of the early yields under screens alone. This adjustment possibly made some compensation for yield variations associated with differences in the bush frame that had been caused by an earlier pruning experiment on the same plots. The analysis of variance for the latter

part of 1952, after the first application of manures, was adjusted in this way. So also was the yield for 1953, after the top-growth made in the first year had been pruned away. Similar results were obtained in both years. The adjusted analysis of variance for 1953 is quoted in Table 4. It will be seen that "Light", although not without meaning, fails to attain an accepted level of significance. This can be understood by reference to the interactions described in Part II (Fig. 6).

Earlier reports on this experiment have not considered the possibility of an adjustment for the original status of the plots. A tendency for light intensities to lose their significance gradually from one year to another has been reported[3]. It seems now that this long term effect might be due, in part at least, to loss of some original bias under the influence of manurial treatment. In Part I it was recorded that Portsmouth[10] perceived important issues left open in the first report on this (and connected) trials[7], but it is to be noted that his belief in the significance of shade was supported by an analysis of variance of the primary data[7] and not the data as adjusted in Tables 3 and 4.

Up to the time of writing we have not had the opportunity of adjusting the yields subsequent to 1953. The adjusted data for that year show manures and nitrogen to be highly significant, but the interactions with light do not attain significance (Table 4). Nevertheless, the ratios of the yield increments associated with light (Table 3) are impressive and agree with data in Part II (Table 6) in suggesting that the magnitude of the sources of nitrogen, and the intensity of the incident light, may determine the nitrogen source which could be most efficiently utilised.

Apart from calcium nitrate, already discussed, the other manures do not call for special comment, except that urea, on a nitrogen basis, was less efficient than ammonium sulphate: this is opposed to the finding of an earlier experiment, described in Part II (Table 7); though in both instances the data suggest an increase in the efficiency of urea and a diminution in the efficiency of ammonium sulphate, under shade conditions.

The concept of Sau-dependence

In Part I it was shown, for populations in general, that a large part of the yield increase under Sau could be ascribed to shade. In Part II it was shown that markedly dissimilar populations are likely to react differently to shade. It therefore becomes necessary to examine the populations in Cooper's trial separately, particularly with reference to the yield increments under Sau trees. As the level of yield differs considerably between populations, the increments due to Sau will be expressed as a percent of the yield without Sau.

Percent yield increments due to Sau are the abscissae in Fig. 6, the ordinates being the percent increase in yield due to ammonium sulphate when it is used under Sau. The regression in Fig. 6 is supported by the analyses of variance in Part I (Table 3). The close ($r = -0.90$) and significant ($P < .001$) relation demonstrates two important principles: firstly, that the efficiency of Sau, in terms of yield, is determined by the tea population; and secondly, it is only when Sau is inefficient that ammonium sulphate is needed.

The tea populations in Fig. 6, raised from distinct sources, are commonly known as *jats* (provenances). Half of the jat-Sau associations give such a small yield increase in response to ammonium sulphate that it is doubtful whether the use of this fertiliser could be justified financially. This is perhaps the most important conclusion to be drawn from Cooper's trial.

Because of the imperfect development of the Sau canopy the relation in Fig. 6 is influenced by some bushes not shaded by Sau and receiving more or less full sunlight. Were the jat-sun relation such that populations nearer to the origin in Fig. 6 gave the greater yield increments in response to ammonium sulphate in sun, and those farthest from the origin gave the lesser yield increments, then one could not strictly ascribe the ordinates in Fig. 6 to ammonium sulphate under Sau. However when the data in Part I (Table 4) were broken down into populations they failed to show any correlation between the yield increments due to ammonium sulphate in sun, and those due to Sau. Fig. 6 may therefore be supposed to represent yield

increments that depend particularly on the Sau-tree-tea-bush association; and these percent increments accordingly define a *Sau-dependence* of the tea bush in respect of yield.

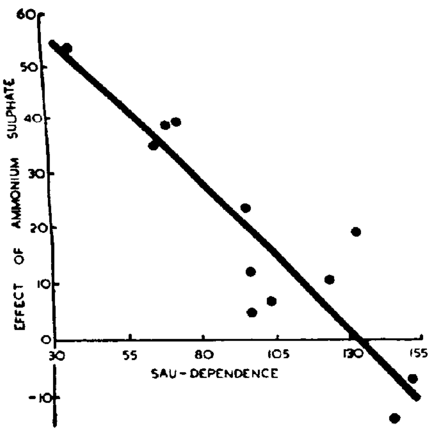

Fig. 6: Percent loss or gain in yield due to ammonium sulphate when used under Sau trees. Data for 12 populations plotted against their yield-dependence on Sau: i.e. the abscissae show the percent by which yield is increased by Sau trees alone. Abscissae designated "Sau-dependence" and ordinates designated "Effect of ammonium sulphate." Percentages computed from the yields of the plots in Cooper's trial for the three years 1949 to 1951.

It is possible to get large percent increments on impracticably low levels of yield. The absolute yield caused by the increment is important: Fig. 7 shows that this is directly proportional ($r = 0.95, P < .001$) to the dependence on Sau as defined. In line with this concept it is found that high absolute yield in full sun, without ammonium sulphate, is attained only by populations with a low Sau-dependence (Fig. 8).

Tea agrotypes[16] could be defined by Sau-dependence. Dansereau[6] describes dependence of one organism on another, whether facultative or obligate, as *biocoenotic integration*. Using this terminology, the basal scale of Figs. 6-8 can be visualised as a scale of *coenotic*, or Sau-dependent, *agrotypes*, thereby introducing the concept of taxonomic ordination. It is to be noted that the scale defines *degrees* of dependence.

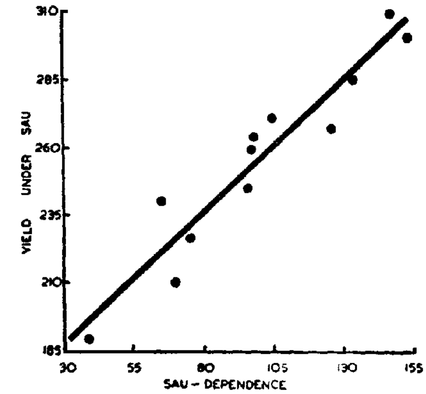

Fig. 7: *Absolute yield of tea populations growing under Sau trees as a function of their yield-dependence on Sau (Sau-dependence). Absolute yield as pounds green weight per 100 bushes. All populations without ammonium sulphate.*

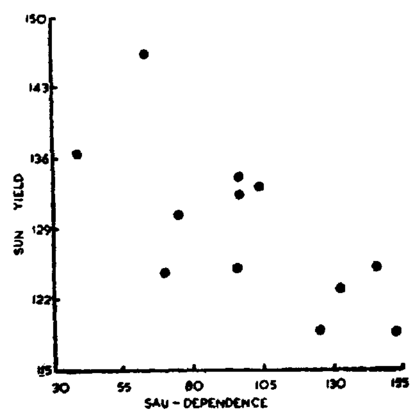

Fig. 8: *Scatter diagram showing that absolute yield in sun tends to be inversely related to yield-dependence on Sau. Ordinates give yield as lbs. green weight per 100 bushes. The correlation co-efficient is* -0.69 $(P < .02)$.

Dependence of tea on Sau is supposed to measure some factors needed by the tea bush, presumably nutritional, provided by the Sau tree, and available to its co-partner. An important question is whether the dependence of tea on Sau, as defined, is obligate or not? Obligation would be a matter of degree.

An *obligate* dependence on Sau for a nutrient element means that the tea bush could not, to the defined degree, utilise the element from any known source except the Sau tree. Thus a fertiliser supplying that element would have the biggest positive influence on the yield of those agrotypes that are least dependent on Sau. This might cause a negative regression of yield on coenotic agrotype; but if the relation were merely facultative then a negative regression would not be expected.

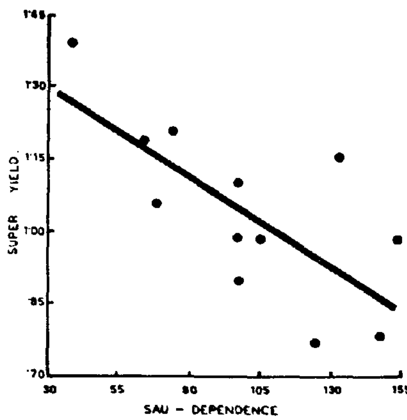

Fig. 9: Relative yield due to superphosphate in shade, estimated as the ratio of the yield due to the joint factors of 'super' and shade, to the yield due to shade alone: this ratio plotted against Sau-dependence. Shade is given by bamboo screens. The correlation-coefficient is -0.71 *(P* $<$ *.01). Yield figures for 12 populations are the average of two years 1955 and 1956 after the alterations in Cooper's trial.*

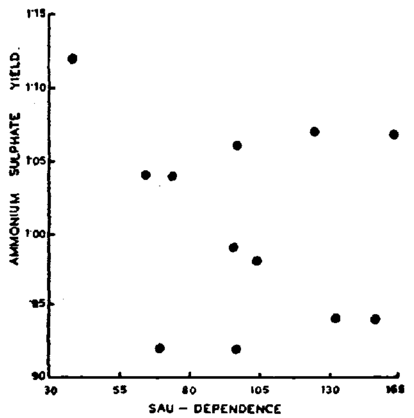

Fig. 10: Relative yield due to ammonium sulphate in shade, estimated as the ratio of the yield due to the joint factors of ammonium sulphate and shade, to the yield due to shade alone: this ratio plotted against Sau-dependence. Shade is given by bamboo screens. Yield figures for 12 populations are the average of two years 1955 and 1956 after the alterations in Cooper's trial. Sau-dependence same as Fig. 9. There is no correlation.

Some idea of the possibility of an obligate relation can be got by plotting population yields on the coenotic agrotype scale. To do this the mean yield under screens for the two years 1955—1956 (Part I, Table 4) was broken down into population yields to give the twelve points in Figs. 9 and 10. In these figures the yield due to the combined factors of shade and fertiliser is expressed as a ratio of the yield due to shade alone. Lack of repeats makes it doubtful whether all the ratios less than unity indicate a real loss or not; but it is reasonable to assume that the trend of the ratios indicates a trend of *relative* magnitude of yield. Expressed in this way, the (relative) yield increments under shade, due to 'super', give a significant negative regression on the coenotic agrotype scale (Fig. 9) whereas the yield increments under shade, due to ammonium sulphate, are distributed at random (Fig. 10). So also are the yields due to shade alone (Fig. 11).

Population dependence on Sau-trees seemingly bears no relation to the yield obtained in response to either shade or nitrogen (as ammonium sulphate): but Sau-dependence of a population is related to its response to superphosphate (under shade). The relation is inverse. This suggests that Sau-dependence, in so far as it is a dependence on nutrients, may be obligate in respect of elements in superphosphate. Phosphorus has been suggested. The data, however, do not give any special reason for supposing an *obligate* dependence in respect of nitrogen; but this does not in any way imply that Sau trees supply no nitrogen, nor that the nitrogen they do supply is not used by the tea bush.

In connection with the foregoing remarks it should be noted, contrary to an earlier suggestion[14], that the twelve populations in Cooper's trial do not show any correlation between the yield increments obtained when ammonium sulphate is used under screens, and the yield increments obtained when ammonium sulphate is used under Sau. Were the dependence of tea on Sau obligate in respect of nitrogen, then a negative correlation might be expected.

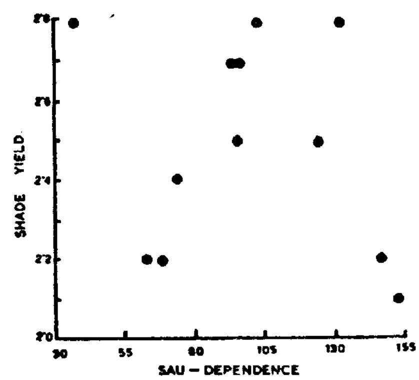

Fig. 11: Yield due to shade, estimated as a ratio of the yield in sun without sulphate of ammonia: this ratio plotted against Sau-dependence. Shade is given by bamboo screens. Yield figures for 12 populations are the average of two years 1955 and 1956 after the alteration in Cooper's trial. Sau-dependence same as Fig. 9. There is no correlation.

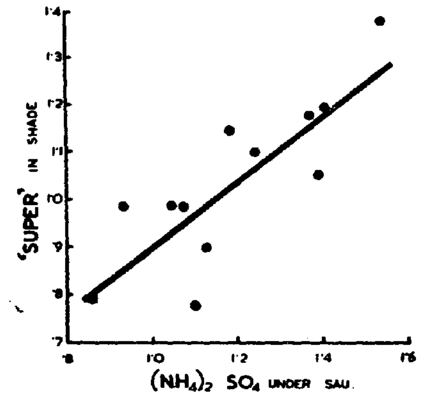

Fig. 12: Yield due to joint factors of superphosphate and screens expressed as a ratio of the yield due to screens alone. Data for 12 populations are the average of two years 1955 and 1956 after the alterations in Cooper's trial. Abscissae are the yield due to joint factors of ammonium sulphate and Sau expressed as a ratio of the yield due to Sau alone. Data from Cooper's trial are the average of three years from 1949 to 1951. The correlation coefficient is 0.82 ($P <$ .01).

However, there is a negative correlation between the yield due to ammonium sulphate under Sau, and Sau-dependence. Were this negative correlation caused by an obligate dependence on Sau in respect of nitrogen, then the population *least dependent* on Sau, with a yield increment of about 55% (Fig. 6) might be expected to show some response to ammonium sulphate used under bamboo screens. It appears not to do so, because other plots, believed to be raised from the same seed source, failed to respond to ammonium sulphate under screens (Part II, Fig. 8). The regression in Fig. 6, therefore, seems unlikely to represent an obligate relation in respect of nitrogen, but it might be a consequence of ammonium sulphate increasing the availability of some other nutrients, phosphorus being a possibility. Along this line of thought one would expect yield increments due to 'super' under Sau to be similar to the yield increments due to ammonium sulphate under Sau: this seems

to be practical experience, but the direct comparison was not possible within the limits of our data (Part I, Table 4). However, the combined effect of 'super' plus shade is strikingly similar to the combined effect of ammonium sulphate plus Sau (Fig. 12), suggesting that part of the yield ascribed to ammonium sulphate under Sau (excluding canopy gaps) might be caused by that fertiliser making phosphorus somewhat more readily available in our soil, particularly in the vicinity of Sau trees. In this connection it is to be noted that evidence was adduced in Part I (Fig. 5) in support of the belief that factors other than nitrogen play an important part in the yield response ascribed to shade.

The yield due to ammonium sulphate under screens does not permit an estimate of yield due to ammonium sulphate under Sau. However, in the light of Fig 12, it seems that important responses of progeny populations to Sau trees might be estimated under screens in the presence of superphosphate. This could lead to considerable simplification of field technique.

While the observed correlations do not provide direct evidence, they give important indications of some possible functions of the Sau tree. There is an absence of replicates, but on the other hand the data are obtained from large populations. All the results are consistent with the interpretation that some factors in superphosphate may be critically important for the utilisation of nitrogen under shade on our soil. The behaviour of the populations suggests that the same, or equivalent factors, may be supplied by Sau trees. There are genetical complications, inherent in tea populations, which call for separate investigation.

Discussion

Three articles, of which this is last, were written to provide factual details of the phenomena too often summarised merely as statistical interactions between nitrogen and shade-trees. In describing the interactions some conclusions in principle are inevitable, especially as comparisons between Sau trees and shade were regarded as fundamental.

It can be stated at the outset that a large part of the effect of Sau trees on yield, and by analogy, a large part of the effect of other trees also, can be ascribed to shade. At the same time, Sau trees seem to make available some nutrients that further increase the yield of shaded tea bushes.

In respect of light intensity, a conclusion of great importance was stated in Part II when it was said "there is a density of shade giving a certain increase of yield of the bush surface that cannot be bettered by using ammonium sulphate under that shade; but lesser shade would give lesser yield that could be increased by ammonium sulphate. The biggest return per pound of ammonium sulphate however, would be got by using large doses in full sun; but should fertiliser be discontinued, yield would drop to a lower level than that obtained under shade alone." This principle has been advanced repeatedly by the author in lectures and memoranda from 1948 onwards. The principle and its application to shade-trees was first formulated by Cooper in 1939: Cooper[1] said "At some level of artificial nitrogen supply we may expect no effect from shade trees. Under a certain density of leguminous shade we can expect no benefit from nitrogenous manures". In the third (1946) edition of Cooper's (*sic*) handbook[5] the statement was "revised" to read "It is generally assumed that at some level of artificial Nitrogen supply, probably more than double the quantity being applied here, we may expect practically no effect from shade trees. Just as under a certain density of leguminous shade we can expect only the minimum benefit from nitrogenous manures". The revision biassed the argument in favour of nitrogenous manures. Cooper, in a private communication (February, 1959) says that the revision of his handbook "may appear to make me responsible for opinions I do not hold."

Experiments with bamboo screens give reason to believe that Cooper's original statement might be amplified and made applicable to a reduction of illumination in general and not necessarily to a reduction by means of leguminous trees. However, in numerous discussions with our colleagues we have been told that yield increments due to screens might not have occurred

in our experiments had the bushes been grown from the start in an unmanured soil, or in soil that had not been under a Sau tree, where lesser amounts of nitrogen would have been circulating between the soil and the tea bush. This possibility has been supposed to invalidate the application of our results to natural soil conditions. However, "natural" unmanured soils can differ much in fertility, and the argument essentially means that no shade response could be expected at sufficiently low levels of nitrogen. To the writer, that is obvious; but the argument should also be applied to nutrients other than nitrogen.

Studies of the effect of shade on the yield of cacao in Trinidad have taken soil fertility into account. This work has been consulted only in abstracting journals, a summary by Murray[9] saying "On soils with low levels of available nutrients, permanent shade would appear essential to maintain trees in a reasonable state of health. Yields, however, will be low. On more fertile soils, shade can be reduced, the condition of the trees will not suffer and yields will be higher. The use of shade on soils of high fertility should not only be unnecessary but would be deleterious to heavy cropping". In this, "shade" presumably means shade-trees. But on our soil the sun- yield of tea could be greater than the yield under shade-trees only in the presence of very large amounts of nitrogenous manure. This suggests, by Trinidad standards, that our soil is one of low fertility; and in line with this suggestion was the necessity for Sau trees in Cooper's trial to maintain the health of some of the populations; though, contrarywise, the yield of the populations under Sau could not be considered low. However, differences between cacao and tea are to be expected from the fact that cacao yield is based on fruits and tea yield is based on cropped shoots: nevertheless, essentially similar interactions between nutrients and shade might influence the yield of both crops, but the relevant soil conditions are not well enough known for useful comparisons.

For the purpose of our investigations a forest soil was accepted as a common start of a tea garden; and, in our experimental plots, located on old grazing land and scrub jungle, it was supposed that fertility had been built up by manuring the tea

bush and returning the prunings to the soil. Given these conditions, we reached the conclusion that shaded tea plants had a very much higher yield than plants in the sun and therefore they removed more nitrogen and other nutrients from the soil. Further manures were not needed for reasonably high yields provided that the bushes were shaded. This condition was maintained for many years. It is evident that there would be a lower limit of fertility below which shade could not be effective, or would cease to be effective, but the limit might be very low : for instance, significant yield increases due to shade were recorded by Barua[9] over a period of six months (a normal plucking season) on small two year old plants growing on soil that had been without manure or fertiliser, and under clean fallow for 25 years.

These investigations suggest that some sources of nitrogen, which must be distinct from added fertiliser, and which we think merit the epithet of "natural" sources of nitrogen, are not fully utilised in the sun. But nitrogenous fertilisers are utilised in the sun, and more efficiently than under shade. Thus, if the manurial level be sufficiently high and equal under both light intensities, then shade might cause a loss of yield. These facts suggest that changes of light intensity cause a differential utilisation of various fractions of soil nitrogen. It is, of course, possible for shade to increase the fixation of nitrogen by micro-organisms, but the magnitude of the yield change, and its rapidity, suggest that possible increases in the fixation of nitrogen are unlikely to be a causal factor : it is more likely that causal factors would be located in the apical meristems.

The long continuance of high yield under shade suggests that some of the nitrogen which is utilised is likely to be in a comparatively insoluble organic form. Lignin compounds have been suggested. It might be that the tea plant is partly heterotrophic under shade, and the presence of mycorrhizae lends some support to this possibility. Such a condition might make it necessary for appreciable amounts of woody matter, like tea-prunings or shade-tree branches, to be added to the soil. Tea-prunings have, in fact, been found beneficial to yield even in the presence of inorganic manures. These considerations have

led us to designate tea cultivation under shade a *silvicultural system*. When tea is cultivated in the sun, especially without the return of prunings to the soil, the system becomes agricultural. The nature of the interactions between illumination and nitrogen make a radical distinction between the two systems. Either system calls for a genetically distinct form of tea plant. In the silvicultural system it would seem necessary to manure the shade-trees.

The Sau tree (*Albizzia chinensis*) was the first leguminous shade-tree to attract attention. It was the only species used in the experiments under discussion. Cooper's experiment showed that Sau trees at least double the yield of tea bushes. After the Sau trees were well established, a major part of the general yield increase, expressed as the gross effect of all populations, could be ascribed to shade. As already discussed, we did not determine the level of soil fertility that is necessary for shade-yield to be higher than sun-yield.

Sau trees introduce factors other than shade. Of these we have been concerned only with nutrients. It can be said that Sau trees fix atmospheric nitrogen and add it to the soil; but the traditional belief that this is their main function, or their only function, is unfounded. The inference is strong that Sau trees supply nutrients additional to nitrogen and essential for its utilisation by shaded tea plants. This condition is of great importance and merits detailed investigation. The patchy and irregular yield responses to shade suggest a patchy and irregular deficiency of something necessary for yield under shade; and such a deficiency might be connected with the irregular and unsatisfactory growth of shade-trees in tea gardens. This has led us to suggest that the manuring of shade-trees with appropriate minor elements might be more profitable than manuring tea bushes.

Lack of response, or possibly negative response, to shade, within a population, would suggest soil deficiencies; but genetic factors, differing between populations, also seem to determine a lack of response to shade. Similarly, genetic factors determine the efficiency of fertilisers under Sau trees and it is necessary to consider this in some detail.

An important feature of the growth of tea bushes under Sau trees is an easily recognisable dependence of tea yield on Sau. The dependence is a matter of degree and differs between populations, at least when the distance between the bushes is within the traditional limits of 4-5 feet. The dependence appears to be obligate in respect of nutrients other than nitrogen. *Obligate* implies, within the limits of our knowledge, that the nutrients concerned can be supplied in suitable form only by Sau trees, or similar trees. The mode of supply might be *via* the tree roots, or *via* fallen twigs and leaves. Phosphorus has been suggested, with mycorrhizae as a possible uptake mechanism. While much of this is conjecture, the yield dependence of tea on Sau is real, and for our soil it was established that ammonium sulphate has value as a fertiliser under Sau only when the populations have a low dependence on Sau: with other populations, ammonium sulphate caused no increase of yield under Sau.

Apart from the genetically conditioned value of ammonium sulphate under Sau, there is, in practice, another value determined by gaps in the tree canopy; there, greater light intensity causes a big increase in the efficiency of ammonium sulphate. Mid-way between the Sau trees, ammonium sulphate might appreciably raise the yield, while having little effect nearer the boles where the light intensity could be at the optimum necessary for maximum shade yield. On that basis it is sometimes said that ammonium sulphate is a practical necessity "under shade-trees". Were the trees a little closer, or their canopies more nearly continuous, then ammonium sulphate midway between the trees might be needless, because the shade there could also be sufficiently dense for maximum yield: but then some loss might be incurred near the boles, due to shade in that position becoming too heavy: but that loss might be balanced by savings of fertiliser. In practice, tree canopies are sometimes thinned because the shade near to the trees is said to be too heavy for maximum yield: this thinning could set up conditions apparently justifying the use of ammonium sulphate, though the reverse might be nearer the truth.

In our experiments superphosphate caused a higher yield under shade (screens) than ammonium sulphate. Thus, gaps in

a Sau tree canopy that make ammonium sulphate efficient, might make 'super' inefficient. In practice, the gaps are frequently very large indeed, possibly larger than the shaded area. When tea is said to be "under" shade-trees, that is often a nominal status, possibly indicative of some original intention, but with little or no relevance to biological efficiency. This has to be borne in mind when considering the results of field trials.

Ammonium sulphate, even in large doses, is likely to have a much lesser effect than Sau trees on yield per unit area of tea bush; but both factors can cause similar increases of bush area. Thus, ammonium sulphate may have little value when the bushes cover the ground; but precisely how much value it does have depends on genetical factors inherent in the population. Depending on the population, shade may cause either a gain or a loss of yield. The magnitude of the yield increment due to ammonium sulphate depends also on the population; but no formal statistical proof of a second order interaction between shade (or Sau), nitrogen, and population, has yet been obtained within the compass of a single field trial; presumably because no trial has included large taxonomic differences. For instance, all the populations in Cooper's trial could be referable to var. *assamica,* and interactions might have been more readily detected had more divergent populations been used. Nevertheless, unpublished work shows that the yield differences associated with the twelve populations, due to the first order interaction between Sau and ammonium sulphate, can be significantly correlated with population measures of the vascular bundle; and this gives some reason to believe in the reality of a second order interaction even within the limits of Cooper's trial.

Different environments make it necessary to cultivate different populations and these have inherently different yields. In practice one needs to know, for each population, the proportionate, or percentage, yield increment due to ammonium sulphate (or comparable fertiliser) used under Sau or other shade-trees. The recognition of differences between populations in terms of these proportionate gains (ratios) does not

logically necessitate a second order interaction. An important practical problem is to establish regressions of the ratios on a scale of significant morphological features expressed numerically. Populations scaled or classified numerically are designated *agrotypes*.

Yield increments due to Sau, expressed as a ratio of the yield without Sau, have been defined as the degree of *Sau-dependence* of the population. While shade is an important factor provided by Sau, the Sau-dependence of a tea population cannot be ascribed solely to its need for shade, nor to its need for nitrogen under shade. The yield increments due to ammonium sulphate properly under the trees, and not in large gaps in the canopy, are *negatively* related to Sau-dependence. It seems likely that these yield increments could be estimated experimentally, on a small scale, by using superphosphate, but not ammonium sulphate, under screens. This has prompted the suggestion that ammonium sulphate under Sau may function partly by making phosphorus more readily available. At the least, the value of Sau plus ammonium sulphate was estimated from the much simpler physical factors of shade and superphosphate.

While this experimental determination of Sau-dependence might be of value, a morphological basis for the phenomenon is desirable. Pubescence of the tea plant is indicative of Sau-dependence. It could therefore be the basis of an agrotype scale indicating the normal yield of a population under Sau, and the increments, if any, that might be expected from ammonium sulphate and other fertilisers with comparable effect on yield. However, better scales are known, including one mentioned in an early report on this work[12]. While comparisons between the several scales are being prepared for publication the present articles form an introduction to the subject in general. It is clear that agrotypic classification is needed before shade-trees and fertilisers can be used efficiently. At the present juncture two things can be said: firstly, there are no grounds for believing nitrogen to be any more important than any other nutrients that might be supplied by Sau trees; and, secondly,

ammonium sulphate as a fertiliser is wasted on some agrotypes growing under Sau trees.

Summary

Much of the data is in the form of non-replicated observations, interpreted as correlations. While these do not provide direct evidence, they indicate possible functions of the Sau tree. This is a leguminous shade-tree (*Albizzia chinensis*) which greatly increases the yield of tea bushes (*Camellia sinensis* var. *assamica*). A large part of the yield increase is due to shade (reduced light intensity) but other factors, presumably nutritional, influence the yield increments under Sau. The magnitude of the increments differs between disparate tea populations. These differences could not be directly associated with either shade or nitrogen. In practice, ammonium sulphate, used as a fertiliser for tea under Sau trees, causes yield increments proportionate to the *lack of increment* caused by Sau in the first place. Nevertheless, the evidence suggests to the author that supplies of phosphorus (and possibly calcium) may be necessary for the efficient utilisation of nitrogen under shade. It is suggested that an important function of the Sau tree is to supply phosphorus to the tea bush. Superphosphate was at least as efficient a fertiliser as ammonium sulphate, either under shade or under Sau. Contrary to traditional belief, the experiments gave no reason for supposing nitrogen to be any more important than any other element that might be supplied by the Sau tree. The experiments indicate a need for fundamental studies of the nutrition of Sau and similar shade-trees.

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AGRICULTURAL BRANCH

S. K. DUTTA—Senior Agriculturist.

S. BASU—Assistant Agriculturist.

K. N. SHARMA—Agronomist.

STAFF

The Senior Agriculturist was on study leave abroad from the 20th April to 30th October, 1958. The Assistant Agriculturist was on annual leave from 2nd January to 31st January, 1958 and on sick leave from 5th March to 8th March, 1958, 10th May to 16th July, 1958 and from 9th October to 8th November, 1958. Mr. W. Hadfield, Advisory Officer (Designate) was in training in this branch for a part of the year and completed the major portion of his training in this branch.

Sri P. C. Barua, Junior Technical Grade Assistant, resigned from his post on 21st January, 1958. Sri Itmadul Huq was appointed as a Junior Technical Grade Assistant on 18th February, 1958 but his services were terminated on 18th November, 1958 at the end of the probationary period. Sri A. C. Sarma joined as a School Teacher at Borbhetta on the 14th May, 1958 in place of Sri S. N. Mahanta who was promoted to the Junior Non-Technical Grade Assistant.

RESEARCH AND EXPERIMENT

Introduction :

46 long and short term experiments were in progress at Borbhetta during 1958. A list of these and a list of the experiments being conducted by this branch in co-operation with the Advisory Officers are given in Appendices at the end of this report. 19 agricultural experiments in the Assam gardens also were taken over by this branch at the end of 1958, making a total of 57 experiments in the gardens of North East India. Short reports on some of these experiments appear as appendices in the respective Advisory Branch reports.

2 short term experiments at Borbhetta were terminated and 7 new experiments and trials were initiated. In the districts, 1 experiment was discontinued and 12 new ones were initiated. The main subjects of study and experimentation both at Borbhetta and in the districts were manuring, shade, plucking, pruning, trial of shade trees and green crop species, cultivation and weed suppression. Results are given in this report and a list of the experiments is given as an appendix. Manurial experiments in particular are again being reviewed in this report and the following is a brief synopsis of some of the more important results in 1958.

In an experiment where urea was applied to tea under *Albizzia odoratissima* shade trees, the urea was effective only when applied as a foliar spray. When urea has been applied broad-cast in the soil in the dry form it has neither produced any increase in yield nor has in any way affected the quality of the made teas.

The comparison between ammonium chloride and sulphate of ammonia was continued. Again no significant difference in yield was observed, but a trend to reduce quality in the made teas was noticed.

In a new experiment it has once again been found that no economy can be made in manures by omitting manure from some of the bushes nearest the shade trees.

The good effects of phosphate in green crops have once again been observed and it has been found that superphosphate is a more efficient form of phosphatic manure than rock-phosphate.

The importance of using suitable manures at the time of planting has been confirmed.

Beneficial results were obtained from limited quantities of organic manures and from phosphate.

One of the experiments on pruning cycles has shown that higher yields can be obtained from unpruned teas, but there is a tendency for reduction of quality of the made teas.

Trials of various species of ground cover crops, green crops and shade trees are continuing. As a result of these, *Desmodium ovalifolium* can be recommended for use as a ground cover crop, particularly for rehabilitation of old nursery sites and uprooted areas. This crop is not considered to be as good as *Calopogonium mucunoides* under Borbhetta conditions. *Calopogonium mucunoides* should not, however, be grown in tea areas as it is a twining creeper. *Indigofera teysmanii* has been under observation, and from preliminary trials it appears that it is worth trying as a green crop in tea provided it is kept adequately lopped, because it has a tendency to become somewhat woody and large. Widely spaced and allowed to grow naturally it might have some value as a temporary shade. In our trials of shade tree species, it has been observed that *Albizzia richardiana* grows very rapidly and unless it is either thinned out or removed quickly it gives dense shade and tends to supress the growth of tea. This indicates that it should only be used as a very temporary shade tree in a mixed stand.

Trials on planting of tea cuttings in "Alkathene" lay flat tubes have shown that it is possible to raise plants successfully in these tubes filled with soil.

One chemical weedicide has shown promising results in controlling 'thatch' (*Imperata* sps.) in young tea.

Comparison of different methods of application of Urea with Sulphate of Ammonia applied broadcast—Expt. No. B.15/2:

This is a new experiment and has not previously been reported.

The object of the experiment is to compare the effects of urea solution sprayed on the foliage of tea bushes with the same amounts of nitrogen applied to the soil as sulphate of ammonia and as urea and applied by different methods.

The tea is a light leaf Assam jat planted in 1928 at $4\frac{1}{4}$ ft. $\times$ $4\frac{1}{2}$ ft. triangular and is under good *Albizzia odoratissima* shade. This experiment with six treatments was started in 1958, after taking preliminary yield records from September, 1957. The layout is of a simple randomised design with 4 blocks having 36 bushes in each plot.

The treatments are :

(1) No manure.

(2) 6.4% urea solution in six rounds foliar spray at fortnightly intervals during April to June, to apply a total of 60 lbs. nitrogen per acre.

(3) 6.4% urea solution in six rounds spray directly on the soil, at fortnightly intervals during April to June, to apply a total of 60 lbs. nitrogen per acre.

(4) 60 lbs. nitrogen per acre as urea, applied broadcast to the soil in the dry form, in one dose in March.

(5) 60 lbs. nitrogen per acre as sulphate of ammonia applied broadcast to the soil in the dry form in one dose in March.

(6) 60 lbs. nitrogen per acre as urea, applied broadcast to the soil in the dry form in one dose in March and six rounds foliar sprays of 6.4% urea solution during April to June, to apply a total of 120 lbs. nitrogen per acre.

Yield of Tea.— 1958 has been the first year of the experiment and the yields from the different treatments are shown below (Table 1) in the descending order :—

Table 1 : Foliar and soil application of urea compared with sulphate of ammonia.

Treatments	Made tea per acre in mds.	Percent increase or decrease when Tr. 1 is taken 100
(5) 60 lbs. nitrogen as sulphate of ammonia applied broadcast to soil	14.28	115.0
(2) 60 lbs. nitrogen as urea by foliar spray	13.26	106.8
(6) 60 lbs. nitrogen as urea by foliar spray and 60 lbs. nitrogen as urea applied broadcast	13.24	106.6
(3) 60 lbs. nitrogen as urea applied to soil in solution	12.44	100.2
(1) No manure	12.42	100.0
(4) 60 lbs. nitrogen as urea applied broadcast to soil	12.22	98.4
Critical Difference (P = ·05) ...	1.13	9.1

There is no significant difference in the yields obtained from Treatments 5, 2 and 6. Treatments 3, 1 and 4 have given significantly lower yields than Treatment 5. Sulphate of ammonia applied broadcast directly to the soil, tends to give the highest yield and urea tends to be effective only when it has been applied in dilute solutions as foliar spray. When urea has been applied to the soil either broadcast in the dry form or applied in a solution, it has failed to produce any significant increase or decrease in yield. It is also seen that in Treatment 6 where 60 lbs. nitrogen as urea has been applied broadcast directly on to the soil in the dry form on top of 60 lbs. of nitrogen as urea in six foliar sprays, the yield is not significantly different from the yield obtained by either 60 lbs. nitrogen as sulphate of ammonia (Treatment 5) or 60 lbs. nitrogen as urea in six foliar sprays. From this it again appears that urea is efficient only when it is applied as a foliar spray.

Liquor and Dry Tea characters on Tasters' Reports.— Representative samples of bulked leaf from all the six treatments were manufactured by using the medium scale rollers on 13 occasions during the period 23rd. May to 31st. October, 1958 and teas were tasted by the Tocklai Taster and a panel of tasters in Calcutta, in order to see whether any of the manurial treatments had any effect on the cup characters of the made teas.

The following attributes were put to statistical analysis :—

Quantity of Tip, Colour of Tip, Colour of Dry Leaf, Colour of Infused Leaf, Colour of Liquor, Strength of Liquor, Quality, Briskness and Valuation.

The attributes in which some differences were observed are as follows:—

(i) *Quantity of tip* :—In *Table 2*, the average tasters' marks scored by the samples are shown.

Table 2 : Tasters' Marks.

Treatments	...	4	1	3	5	6	2
Tasters' marks	...	41.2	39.8	37.8	35.5	30.2	28.8
Critical Difference required (P = .05) ...				...	8.9		

It appears that in Treatments 6 and 2 where the bushes were given foliar sprays of urea solutions, the quantity of tip is lower, but otherwise neither urea nor sulphate of ammonia has reduced the quantity.

(*ii*) *Quality*:—In *Table 3*, the average marks given by the tasters are shown.

Table 3 : Tasters' marks.

Treatments	...	4	1	3	6	2	5
Tasters' marks	...	52.3	50.0	42.7	41.9	41.5	38.1

Critical Difference required (P = .05) 9.2

It appears that foliar spray of urea and application of sulphate of ammonia have tended to reduce the quality of the made teas, but urea has had no effect when applied broadcast on the soil in the dry form.

(*iii*) *Colour of Liquors*:—The average marks given by tasters are shown in *Table 4*.

Table 4 : Tasters' marks.

Treatments	...	1	4	2	3	5	6
Tasters' marks	...	51.2	47.7	44.6	43.1	41.5	40.0

Critical Difference required (P = .05)... ... 7.2

Here sulphate of ammonia has not made the colour of the liquor any inferior to that produced by urea applied broadcast to the soil in the dry form, although it has produced inferior colour to that obtained from application of no manure.

(*iv*) *Strength of Liquor* :—The average tasters' marks are shown in *Table 5*.

Table 5 : Tasters' marks.

Treatments	...	1	4	3	6	5	2
Tasters' marks	...	50.0	49.2	43.1	41.2	40.0	39.2

Critical Difference required (P = .05)... ... 8.4

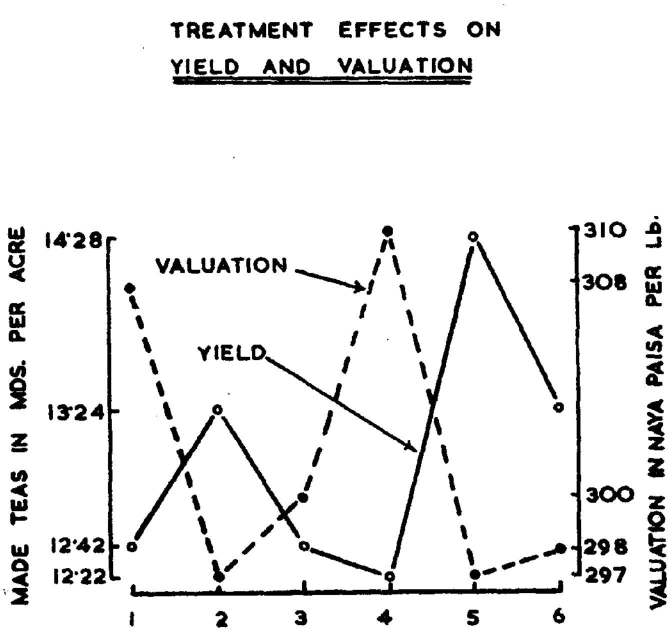
Here also urea applied broadcast to the soil in the dry form in one dose, has not lowered the strength, whereas sulphate of

ammonia applied broadcast to the soil in one dose in the dry form has significantly lowered the strength.

None of the other attributes have shown any significant differences. It is already known that most fertilisers that increase yield, also bring about a slight reduction in the the standard of the cup characters. Here, urea, particularly when applied to the soil, has not produced any increase in yield and hence, it has not in any way affected the cup characters. It has also been seen that although sulphate of ammonia has brought about a reduction of the standard of some of the attributes of the cup characters, it has not reduced the valuation significantly and any small loss in quality will be more than compensated by the high increase in yield.

Economics.— Treatment effects on valuation and yield.

Figure 1 : Yield in maunds per acre and valuation in naya paisa under different treatments.

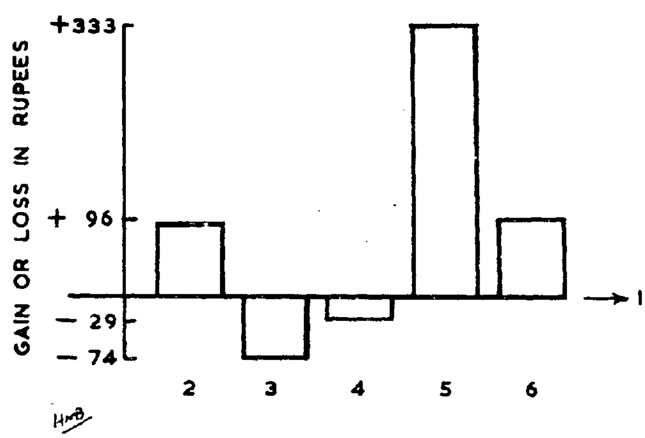


The above *Figure* shows clearly that wherever the yield has been increased, the valuations of the made teas have gone down and the valuations have gone up only where there has been no increase in crop.

The *Figure* below shows the gain or loss of gross income in rupees per acre from the different treatments as compared to the treatment where no manure has been applied.

Figure 2 : Gain or loss in rupees per acre from the different treatments over no manure.

GAIN OR LOSS OF GROSS INCOME IN RUPEES PER ACRE OVER TR. I (NO MANURE)



It is seen that wherever urea has been applied to the soil either as a solution or in the dry form (Treatments 3 and 4) there has been a loss of gross income and the highest gross income has been from the application of sulphate of ammonia and the next in order is when urea has been applied as a foliar spray (Treatments 2 and 6). In estimating the net gain or loss to the garden, the cost of the fertiliser and its application has also to be taken into account.

Manurial trial with Sulphate of Ammonia Vs. Ammonium Chloride —Expt. No. B.28.1 :

This experiment was started in 1956, but has not previously been reported.

The object of this experiment is to find the difference, if any, on the yield and quality of tea using sulphate of ammonia and ammonium chloride.

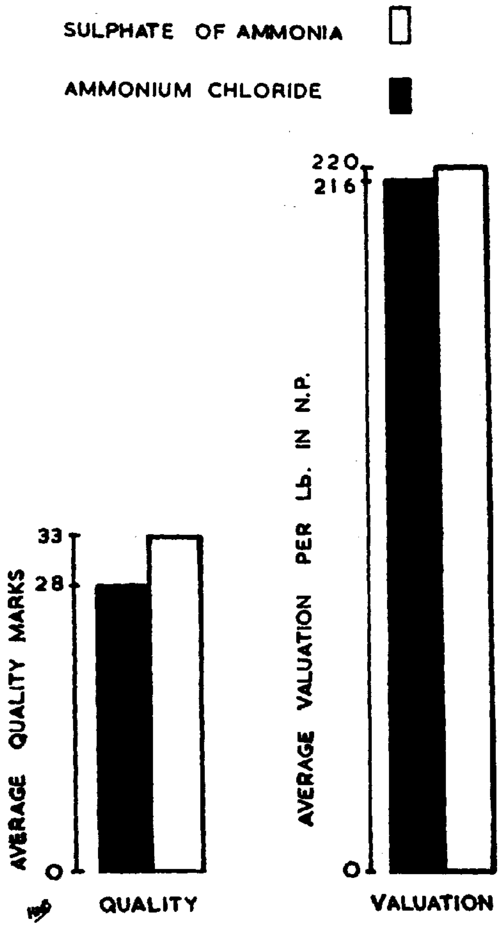
The area was planted with Doolia jat in December 1936 at 4 ft × 4 ft. triangular. The shade was young trees of *Albizzia odoratissima.* The layout was in randomised blocks with 11 replications. The treatments were 80 lbs. nitrogen per acre as sulphate of ammonia and as ammonium chloride. The experiment was started in 1956 after taking preliminary yield records up to June, 1956.

Table 6 : Yield of made tea.

Treatments	Year	1956	1957	1958	Average
Sulphate of Ammonia	Mds. per acre	8.06	11.25	10.84	10.05
Ammonium chloride	Mds. per acre	8.19	11.25	11.30	10.25

The yield differences between the treatments in all the three years were not significant (*Table 6*). Manufacturing trials were done during the year 1958. Representative samples of bulked leaf from all the replications of both the treatments were manufactured by using the medium scale rollers on 10 occasions during the period 27th May to 14th October, 1958 and teas were tasted by the Tocklai Taster for Quantity of Tip, Strength of Liquor, Quality and Briskness, and were evaluated. There was no statistically significant difference between the two treatments so far as made tea was concrned, but it appeared that there was a trend to reduce quality and valuation owing to the use of ammonium chloride (*Figure 3*). Further manufacturing trials will be done in 1959. The chlorine content of green leaf samples have been estimated by the Senior Physical Chemist and is reported in the Physico-Chemical Branch Report.

Figure 3 : Average quality marks and average valuation in naya paisa per pound of made teas from the plots receiving sulphate of ammonia and ammonium chloride.



Different Shade Tree species and effect of Phosphate and Potash — Expt. No. B.1A :

This experiment was last reported in the 1957 Annual Report to which reference should be made.

The object of the experiment was to study the effects of different shade tree species and the effect of phosphate and potash separately and in combination on the yield of tea. The area was planted in 1939 with Khorijan jat at 4½ ft. triangular and the shade trees were planted in October, 1941. The layout was of a split plot design, and the plots were split first for manuring. The shade trees species were randomised in 4 blocks with 32 plots each, each plot having 107 bushes. The manuring treatments per acre were—(1) 40 lbs. potash, (2) 40 lbs. phosphate, (3) 40 lbs. potash + 40 lbs. phosphate, (4) No manure. There were seven shade tree species and a Check having no shade—(1) No shade tree, (2) *Aleurites montana*, (3) *Albizzia chinensis* (Red), (4) *Albizzia chinensis* (Green), (5) *Albizzia odoratissima*, (6) *Albizzia procera*, (7) *Derris robusta* and (8) *Dalbergia assamica*. Results up to 1957 have already been reported in 1957 Annual Report.

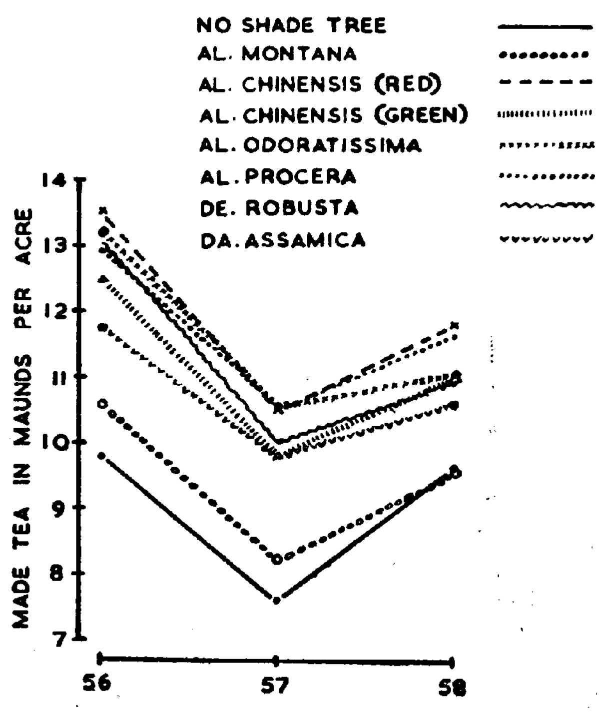
Manures.— Application of potash and phosphate or their combination continued to fail to produce any significant effect on the yield of made teas (*Table 7*).

Table 7 : *The yield of made tea in maunds per acre from potash and phosphate or their combination treatments from 1948 to 1958.*

Treatments / Year	40 lbs. K_2O per acre	40 lbs. P_2O_5 per ccre	40 lbs. K_2O + 40 lbs. P_2O_5 per acre	Without K_2O or P_2O_5
1948	19.55	19.56	20.19	19.75
1949	18.56	18.90	19.31	18.21
1950	16.05	16.68	16.85	15.97
1951	13.31	13.59	14.42	13.17
1952	13.40	13.77	14.42	12.83
1953	10.65	10.86	11.72	10.25
1954	11.20	11.61	12.81	11.24
1955	11.83	11.22	13.16	11.07
1956	12.24	11.23	13.61	11.64
1957	9.70	9.00	10.30	9.50
1958	11.04	9.72	11.78	10.70

Application of nitrogen was stopped from 1948 to 1957 but from 1958 application of 80 lbs. nitrogen per acre has been resumed. The benefit of nitrogen applied could be observed in tea up to 1949 but afterwards there was a steep decline of yield under all shade tree species up to 1952. From 1952 the yield became rather stable except in 1957 where it showed a further decline but this was possibly due to the abnormal season. In 1958 the yield of tea under all the species of shade trees had gone up due to the application of nitrogen but the rate of increase under no shade appeared to be more rapid, as nas already been found that the efficiency of nitrogen is higher in tea without any shade than in the tea under shade (*Figure 4*).

Figure 4 : Yield of made teas in maunds per acre under different species of shade trees and no shade during 1956-1958.



Shade.— The responses of different species of shade trees were almost the same as in previous year except that *Aleurites montana* tended to produce a lower yield than no shade, the difference in yield being not significant (*Table 8*).

Table 8 : Yield in maunds per acre under different species of shade trees during 1958.

Shade tree	Yield in mds. per acre
Albizzia chinensis (Red)	11.82
Albizzia procera	11.66
Albizzia odoratissima	11.18
Albizzia chinensis (Green)	10.98
Derris robusta	10.94
Dalbergia assamica	10.63
Check	9.70
Aleurites montana	9.50
Critical Difference at 5% level	0.76

Manuring under Shade Trees—Expt. No. A.14 :

This is a new experiment and has not previously been reported. Parallel experiments were reported in Annual Report for 1956, to which reference can be made.

The object of the experiment is to ascertain whether nitrogenous manures applied to hedge planted tea under shade have the same efficiency on the bushes nearer the trunk of the shade trees as on the tea bushes away from the trunk of the trees and whether it is possible to economise in manures by omitting this from certain bushes under the trees.

This experiment was laid out in Section 6. Kaliapani Division, Duklingia T. E. in February, 1958. The *jat* of the tea is Khorijan and was planted in cold weather 1949-50 at 5 ft. × 2 ft. spacing. The shade trees are *Albizzia odoratissima*, planted in 1950.

The layout of the experiment is of the randomised blocks design and the following treatments have been replicated four times—(1) No manure in the whole plot of 116 bushes, (2) The inner circle of 36 bushes only manured @ 80 lbs. nitrogen per acre, (3) The outer circle of 80 bushes manured @ 80 lbs. nitrogen per acre, (4) The whole plot of 116 bushes manured @ 80 lbs. nitrogen per acre, (5) The inner circle of 36 bushs only receiving the total quantity of manure required for the whole area and (6) The outer circle of 80 bushes receiving the total quantity of manure of the whole plot. Preliminary yield records were collected till the 1st. July 1958 and manures were applied in the 1st. week of July 1958. The results of the first year of the experiment are, however, based on records collected from the 8th July 1958 onwards only.

The yields in 1958 from the different treatments are shown in *Table 9.*

Table 9 : Yield of made tea per acre.

Treatment No.	Description of treatment	Average rate of application for whole plot. Pounds Nitrogen per acre	Yield in maunds made tea per acre
1	No manure	Nil	15.13
2	Inner circle manured @ 80 lbs nitrogen per acre	24.82	15.75
3	Outer circle manured @ 80 lbs. nitrogen per acre	55.17	16.16
4	Whole plot manured @ 80 lbs. nitrogen per acre	80.00	17.44
5	Inner circle manured with total quantity for whole plot (i.e. @ 263.5 lbs. nitrogen)	80.00	16.97
6	Outer circle manured with total quantity of manure for whole plot (i.e. @ 112.2 lbs. nitrogen)	80.00	16.77
Critical Difference required (P=.05)			1.12

From the above table, it is noticed that the order of yield from the six different treatments has been as folloows :—

Tr. 4 > Tr. 5 > Tr. 6 > Tr. 3 > Tr. 2 > Tr. 1

The results show that the maximum yield is obtained only when the manure is applied uniformly to all the bushes and that if any attempts are made to economise in manures by omitting to manure either the bushes in the immediate vicinity of the shade trees or by omitting to manure the bushes away from the shade trees, there are significant reductions in yield.

It is also seen that when no attempt is made to economise in manure, but instead to omit manures from some of the bushes either in the immediate vicinity of the shade trees or remote from the shade trees and apply the manure thus saved as an extra quantity to the other bushes, there is no significant loss in yield. There are, however, indications that there is some reduction in yield when manure is omitted from some of the bushes. The results also show that when the bushes away from the shade trees are not manured, the loss in yield is biggest, but when no attempts are made to economise in manures, and yet some bushes are not manured the loss is least when the whole quantity of manure is applied to the bushes in the immediate vicinity of the shade trees.

These results are from the first year of the experiment only and no final conclusions can be drawn till results for a number of years become available. These results from tea under 8 years old *Albizzia odoratissima* shade do, however, confirm our previous findings that on tea under *Dalbergia assamica* shade trees (Annual Report 1956, pages 66-68) and tea under *Albizzia chinensis* shade trees (Quarterly Report for quarter ending 30th June, 1950), that the maximum yield is obtained only when all the bushes are manured at a uniform rate.

Manuring of Green Crop and its residual effect on Young Tea.—Expt. No. B.103 :

The object of the experiment was to study the effect ot different levels of phosphate, potash and calcium and their

combinations when applied to a green crop (*Crotalaria anagyroides*) firstly on growth of the green crop itself and subsequently on the growth of young tea. The treatments were—three levels of phosphate as superphosphate—0 lb., 40 lbs. and 80 lbs. P_2O_5 per acre, three levels of potash as sulphate of potash—0 lbs., 40 lbs. and 80 lbs. K_2O per acre and two levels of calcium as slaked lime—0 md. and 4 mds. lime per acre and their combinations.

There were 3 blocks of 18 plots, each plot having 7 rows of green crop *Crotalaria anagyroides* was planted in the last week of April, 1957 at 2½ ft. apart. In each plot 4 alternate rows of green crop were uprooted in February, 1958 and 4 rows of tea were planted in their places in April, 1958, to study the residual effect. The remaining 3 rows of green crop were maintained, lopped and green matter added to the plot. The results of 1957 were published in the Annual Report 1957.

The total green matter added in one lopping during 1957 and 3 loppings during 1958 season showed a favourable response to phosphate. The effect of phosphate on the lopping weights was highly significant. 80 lbs. of phosphate as superphosphate significantly increased the green matter lopped, over 40 lbs. of phosphate which was in turn better than no phosphate (*Table 10*).

Table 10 : Weight of green crop loppings in lbs. due to phosphate application (1957-58).

	P_0	P_{40}	P_{80}	C.D. at 5% level
Yield in lbs. per acre	83758	118512	141963	11670

It is evident from the above results that it is highly beneficial to apply 1 lb. of superphosphate per 40 running feet of green crop. Therefore, the actual requirements of superphosphate (20% P_2O_5) per acre will be 400 to 435 lbs. when rows are 2½ ft. apart. When rows are 5 feet apart the quantity will be 200 to 217 lbs. per acre. The fertiliser should, if possible, be drilled in with the green crop seed. Where this is not

possible, the superphosphate should first be applied in six inch bands along the drills prior to sowing the seeds.

Different Doses of Nitrogen with and without Phosphate at the Time of Transplanting of Seedling.—Expt. No. B. 44B/3:

This experiment was started and completed in 1957/58

The object of the experiment was to study the effect of varying doses of nitrogen in different forms with and without phosphate on the stand and growth of young tea when applied in the pits at the time of planting one year old seedlings. The treatments per plant or per hole were —(i) No manure, (ii) cattle manure (0.5% nitrogen)—10 lbs., (iii) Oilcake (5% nitrogen)—8 ozs., 12 ozs. and 1 lb. (iv) Sterameal (Sterilized animal carcass meal, 7% nitrogen, 10% P_2O_5)—6 ozs., 9 ozs. and 12 ozs., (v) Superphosphate (20% P_2O_5)—1 oz alone, (vi) cattle manure—10 lbs. + 1 oz. superphosphate, (vii) Oilcake 6 ozs. + 1 oz. superphosphate, (viii) Oilcake —12 ozs. + 1 oz. superphosphate and (ix) Oilcake —1 lb. + 1 oz. superphosphate —thus making 13 treatments (*Table 11*). The layout was randomised blocks with 3 replications having 20 seedlings per nett plot planted at 2 ft. × 2 ft. One year old seedlings were planted in the 4th week of November, 1957 in holes 18″ wide and 18″ deep. Manures were well mixed with the soil and filled in before planting. Care was taken to select the seedlings of almost the same height for planting. Survival counts were taken 2 months after planting whereas other growth characters like weight of shoots and roots, height and girth of plants were taken 14 months after planting.

Mortality.— There was no mortality of plants in plots which received no manure or 1 oz. of superphosphate or 10 lbs. of cattle manure. Application of 1 lb. oilcake with or without phosphate, as well as 9 ozs. and 12 ozs. "Sterameal" significantly decreased the percentage of survivors (*Table 11*).

Mean weight of Shoots.— Application of 10 lbs. cattle manure per plant without (Tr. 2) or with phosphate (Tr. 10) produced significantly higher shoot weights as compared to other treatments. Tr. 11 was significantly superior to Tr. 1. Other treatments were not significantly better than no manure

Application of cattle manure without or with 1 oz. superphosphate and 8 ozs. oilcake with 1 oz. superphosphate proved to be significantly beneficial for the height of shoots (*Table 11*).

Table 11 : Percentage of Survival, Mean weight of Shoots, in kgm., Mean weight of roots in gms., Mean height and mean girth per plant in inches under different treatments.

Treatment Nos.	Treatments	% Survivors	Mean weight of shoots in kgms.	Mean weight of roots in gms.	Mean height in inches	Mean girth in inches
1	No manure	100	2·3	733	30·75	0·62
2	C.M.—10 lbs.	100	5·9	1633	45·17	0·82
3	O. C.— 8 ozs.	87	2·7	867	35·57	0·703
4	O. C.—12 ozs.	92	3·0	1100	36·17	0·72
5	O. C.— 1 lb.	65	2·6	800	35·08	0·73
6	S. M.— 6 ozs.	93	2·5	933	34·55	0·70
7	S. M.— 9 ozs.	68	1·7	667	29·76	0·66
8	S. M.—12 ozs.	68	1·3	333	30·76	0·65
9	No nitrogen + S. P.— 1 oz.	100	2·2	767	33·57	0·68
10	C.M.—10 lbs. + S.P.— 1 oz.	98	5·6	1400	43·39	0·80
11	O.C.— 8 ozs. + S.P.— 1 oz.	98	3·8	1467	40·33	0·78
12	O.C.—12 ozs. + S.P.— 1 oz.	85	3·03	1000	38·19	0·77
13	O.C.— 1 lb. + S.P.— 1 oz.	75	1·9	633	31·72	0·67
C. D. at 5% level of significance		15	1·2	390	5·74	0·09

C.M.—Cattle manure ; O.C.—Oilcake ; S.M.—Sterameal ; S.P.—Superphosphate.

Mean weight of roots.— 10 lbs. of cattle manure without or with 1 oz. superphosphate and 8 ozs. of oilcake with 1 oz. superphosphate significantly increased the mean weight of roots per plant as compared to no manure but failed to produce any significant difference when compared among themselves. The application of 12 ozs. of "Sterameal" (Tr. 8) significantly reduced the mean weight of roots over no manure, whereas the differences from rest of the treatments over no manure were not significant (*Table 11*).

Mean height per plant.— 10 lbs. of cattle manure without (Tr. 2) or with 1 oz superphosphate (Tr. 10), 8 ozs. of oilcake with 1 oz. superphosphate (Tr. 11), 12 ozs. oilcake with 1 oz. superphosphate (Tr. 12) produced significantly taller plants as compared to no manure. Tr. 2 was superior to Tr. 12 but was not significantly different from Tr. 10 and Tr. 11. Other manurial treatments failed to produce significant superiority over no manure.

Mean girth per plant.— Like the other attributes of the growth characters Tr. 2, Tr. 10, Tr. 11 and Tr. 12 produced significantly thicker stems than no manure. Besides these, application of oilcake at 12 ozs. (Tr. 4) or 1 lb. (Tr. 5) per plant was also better, but the other treatments did not produce any superiority over no manure (*Table 11*).

Under the conditions of this experiment it was evident that application of 10 lbs. of cattle manure per pit at the time of planting seedlings was the most beneficial for the growth of the tea seedlings. When 1 oz. of superphosphate was added to the cattle manure no improvement in growth was shown. Cattle manure is not always available in large quantities and hence, under these circumstances, 8 ozs. of oilcake with 1 oz. superphosphate may be used with results equally as good as cattle manure. Application of oilcake over 12 ozs. per hole does not appreciably increase growth over the 8 ozs. application. In this experiment application of "Sterameal" even at 6 ozs. per hole was not in any way better than no manure, but on the other hand higher doses had a tendency of showing deleterious effects on the growth and survival percentage of plants.

Rockphosphate trial on Green Crop with residual effect on Young Tea.—Expt. No. B. 2B.1 :

This is a new experiment and has not previously been reported. This experiment has also been mentioned in the current Physico-Chemical Branch report, to which reference should be made.

The object of the experiment was to study the relative efficiency of rockphosphate and superphosphate with or without potash on green crop *Crotalaria anagyroides* and subsequently the residual effects on the growth of young tea. The treatments were—(1) Check—no manure, (2) Rockphosphate @ 80 lbs. P_2O_5 per acre, (3) Superphosphate @ 80 lbs. P_2O_5 per acre, (4) Rockphosphate @ 80 lbs. P_2O_5 per acre + Sulphate of Potash @ 40 lbs. K_2O per acre, (5) Superphosphate @ 80 lbs. P_2O_5 per acre + Sulphate of Potash @ 40 lbs. K_2O per acre. Green crop *Crotalaria anagyroides* was drilled in rows 2½ ft. apart on 26th March, 1958 with the fertilisers. The tea will be planted in March/April, 1959. The layout was randomised blocks with four replications.

The height measurements were taken on 11th July, 1958 (16 weeks after sowing). Application of superphosphate significantly increased the height of *Crotalaria anagyroides* as compared to rockphosphate and no manure. The differences among Treatments 1, 2 and 4 were not significant (*Table 12*)

Table 12 : Average height in inches of Crotalaria anagyroides plants and weight in lbs. of loppings at 3 ft.

Treatments	1 No manure	2 Rock phosphate	3 Super phosphate	4 Rockphosphate+ Sulphate of Potash	5 Superphosphate + Sulphate of Potash	C. D. at 5% level
Average height per plant in inches ...	57·7	59·6	74·4	65·1	78·8	12·7
Weight of loppings in lbs. per acre on 19.7.58	1014	1113	3538	1770	4464	1045

The first lopping of green crops was done on 19th July, 1958 (after 15 weeks of sowing) at 3 ft. height above the ground level. There was no significant difference in lopping weights between the application of superphosphate alone and in combination with sulphate of potash, but produced significantly higher lopping weights as compared to rockphosphate alone or in combination with sulphate of potash and no manure. Rockphosphate failed to produce any superiority even over no manure (*Table 12*).

The second lopping was done on 24th September, 1958 (26 weeks after sowing) at 3½ ft. height. The effects of the forms of manures only were significant. The over-all effects of superphosphate produced significantly higher lopping weights, than rockphosphate. When 80 lbs. of P_2O_5 per acre was applied either as superphosphate or as rockphosphate, the addition of 40 lbs. of potash per acre, did not produce any change in the responses (*Table 13*).

Table 13 : Weight of Crotalaria anagyroides loppings at 3½ ft. above ground level in lbs. per acre on 24.9.58.

	80 lbs. P_2O_5 per acre	80 lbs. P_2O_5 per acre + 40 lbs. K_2O per acre	Average
Superphosphate	4610	4502	4556
Rockphosphate	2729	3166	2948
Average	3670	3834	

Critical difference (P = ·05) between means of phosphatic forms of manure ... 1336 lbs.

The results of this experiment showed that potash had not benefited the green crop, that phosphate application was beneficial, and that superphosphate was the more efficient form than rockphosphate.

The Physico-Chemical Branch has investigated the uptake and recovery of prosphates by the green crop in this experiment and reference can be made to the current report of that Branch.

Different Pruning Cycles—Expt. No. B.22.1 :

This experiment was last reported in the Annual Report for 1955 to which reference can be made.

The object of the experiment is to determine the long term effects of four different pruning cycles on the total yield, crop distribution, quality and valuation of the made teas, kind of shoots obtained from the tea pruned differently, and pest and disease susceptibility of the bushes under the different treatments.

This experiment is being conducted in a section of Dark Leaf Manipuri kind of tea (Rajgarh), planted in 1924 at 4½ feet triangular spacing without any shade. There are four treatments as follows :—

Treatment 1 :—	1st. year, prune 1″ above the previous pruning level.
	2nd. year. heavy skiff by leaving 3″ new wood.
	3rd. year, skiff ½″ above the previous skiffing level.
Treatment 2 :—	1st. year, prune 1″ above the previous pruning level.
	2nd. year, levelling off skiff above last plucking round.
	3rd. year. Deep skiff to 8 inches above the pruning level.
Treatment 3 :—	1st. year, prune 1″ above the previous pruning level.
	2nd. year, prune ½″ above the previous pruning level.
	3rd. year, levelling off skiff above last plucking round.
Treatment 4 :—	1st. year, prune ½″ above the previous pruning level.
	2nd. year, prune ½″ above the previous pruning level.
	3rd. year, prune ½″ above the previous pruning level.

The above four treatments have been replicated four times in randomised blocks and each plot consists of 100 tea bushes.

Preliminary yields were taken in 1948 and all subsequent yields have been related to these by co-variance analysis. The first treatments were applied in the cold weather of 1949-50 and the treatments and the yields have been as follows (*Table 14*).

First Cycle :

1950 ... As a result of pruning all the treatments in the similar manner in the cold weather 1949-50, there was no significant difference between any of the treatments.

1951 ... The plots that were skiffed only to level off (Treatment 2) gave significantly higher yields than all the other plots (C.D. required at $P = 0.05$ is 1.17 maunds per acre).

1952 ... The plots that were either deep skiffed or skiffed to level off (i.e. Treatments 2 and 3) gave significantly higher yields than the other plots (C.D. required at $P = 0.05$ is 1.39 maunds per acre).

There were no real differences between the yields of plots under Treatments 1 and 4.

Whole Cycle :

1950-52 ... When the total yields of the three years *i.e.* of the 1st. cycle are compared, it is evident that the plots under Treatment 2 gave the highest yield followed by the plots under Treatment 3.

Second Cycle :

1953 ... In this year when all the treatments were pruned and all the treatments except 4, were pruned on wood that was more than one year old, Treatment 4 gave significantly higher yield ($P < 0.01$) than Treatments 1 and 2 which

Table 14 : Operation and Yield Details.

Cycle	Year	Treatment 1		Treatment 2		Treatment 3		Treatment 4	
		Operation	Yield in mds. per acre	Operation	Yield in mds. per acre	Operation	Yield in mds. per acre	Operation	Yield in mds. per acre
I	1949-1950	Prune 27″ Pluck 35″	15.36	Prune 27″ Pluck 35″	16.29	Prune 27″ and clean out by knife. Pluck 35″	16.09	Prune ½″ up and clean out by knife. Pluck 8″ to janam	15.96
I	1950-1951	Heavy skiff to 30″ Pluck 36″	10.78	Skiff to level off. Pluck 37″	13.16	Prune 27½″ Hand banjhi. Pluck 35½″	11.13	-Ditto-	10.46
I	1951-1952	Skiff 30½″ Pluck 36½″	11.71	Deep skiff to 35″ Pluck 37″	13.64	Skiff to level off. Pluck 37½″	14.74	-Ditto-	11.30
Total yield of 1st. Cycle ...			37.85		43.09		41.96		37.72
II	1952-1953	Prune 28″ Pluck 36″	7.71	Prune 28″ Pluck 36″	7.69	Prune 28″ Knife clean out Pluck 36″	8.64	-Ditto-	9.74
II	1953-1954	Heavy skiff 31″ Pluck 37″	13.43	Skiff to level off. Pluck 38″	14.54	Prune 28½″. Hand banjhi Pluck 36½″	14.35	-Ditto-	13.25
II	1954-1955	Skiff 31½″ Pluck 37½″	13.04	Deep skiff to 36″ Pluck 38″	14.93	Skiff to level off. Pluck 38½″	15.29	-Ditto-	12.35
Total yield of 2nd. Cycle ...			34.18		37.16		38.28		35.34

Cycle	Year	Treatment 1		Treatment 2		Treatment 3		Treatment 4	
		Operation	Yield in mds. per acre	Operation	Yield in mds. per acre	Operation	Yield in mds. per acre	Operation	Yield in mds. per acre
III	1955-1956	Prune 29″ Pluck 37″	11.61	Prune 29″ Pluck 37″	12.95	Prune 29″ Knife clean out Pluck 37″	14.93	Prune ½″ up and knife clean out. Pluck 8″ to janam	13.98
III	1956-1957	Heavy skiff 32″ Pluck 38″	10.96	Skiff to level off Pluck 39″	14.07	Prune 29 ½″ Hand banjhi Pluck 37½″	11.82	-Ditto-	10.85
III	1957-1958	Skiff 32½″ Pluck 38½″	13.79	Deep skiff to 37″ Pluck 39″	15.00	Skiff to level off Pluck 39½″	15.74	-Ditto-	13.96
Total yield of 3rd. Cycle ...			36.36		42.02		42.49		38.79
Total yield of 3 Cycles ...			108.39		122.27		122.73		111.35

Critical Difference for total yields of 3 Cycles (P = 0.01) ... 8.31 mds

Critical Difference for total yields of 3 Cycles (P = 0.05) ... 5.48 mds.

were pruned on to 3 year old wood. There was no significant difference in yields of Treatments 4 and 3. Treatment 3 was pruned on to 2 year old wood only during the previous prune. (C.D. required at $P=0.05$ is 1.33 maunds per acre). This shows that the older the wood on which the tea is pruned, the lower is the yield in the following year.

1954 ... Although there was a tendency to produce higher yields by the skiffed treatments, there was no significant difference in the yields of any of the four treatments.

1955 ... Plots that were skiffed to level off (Treatment 3) gave significantly higher yields than the plots under Treatments 1 and 4 which were pruned. Treatment 2 which was deep skiffed, gave significantly higher yield than Treatment 1 whereas there was no significant difference between Treatments 3 and 2 (C.D. required at $P=0.05$ is 2.08 maunds per acre).

Whole Cycle :

1953-55 ... The total yields of the 2nd. cycle showed that Treatments 2 and 3 gave the highest yields although Treatment 2 was a little lower than Treatment 3. This again shows that light skiff followed by a deep skiff, and levelling off skiff in one year out of three, increase yield.

Third Cycle :

1956 ... In this year, when all the treatments were pruned, Treatments 3 and 4 where the pruning was done on two and one year old wood respectively, gave significantly higher yields (C.D. required at $P=0.05$ is 2.13 maunds per acre), than Treatment 1. There was no significant difference between the yields of Treatments 2, 3 and 4 and also between the yields of Treatments 1 and 2.

1957 ... Treatment 2 which received a levelling off skiff only, produced the highest yield (C.D. required at P=0.05 is 2.10 maunds per acre). There was no significant difference between the yields of the other three treatments.

1958 ... This year although there was an indication of the Treatments 2 and 3 *i.e.* where the plots were deep skiffed after a levelling off skiff the previous year and skiffed to level off only respectively, to give the highest yields, there was no significant difference.

Whole Cycle :

1956-58 ... In the total yield of the 3rd. cycle *i.e.* in the total yields of 1956 to 1958, the treatments receiving levelling off skiff in one year out of three and the Treatment receiving a levelling off skiff followed by a deep skiff in the 3rd. year, produced at least 8% more crop than the annual prune treatment.

Total Yield of 3 Cycles : The total yields of the different treatments are shown in Table 15 in the descending order in maunds of made tea per acre.

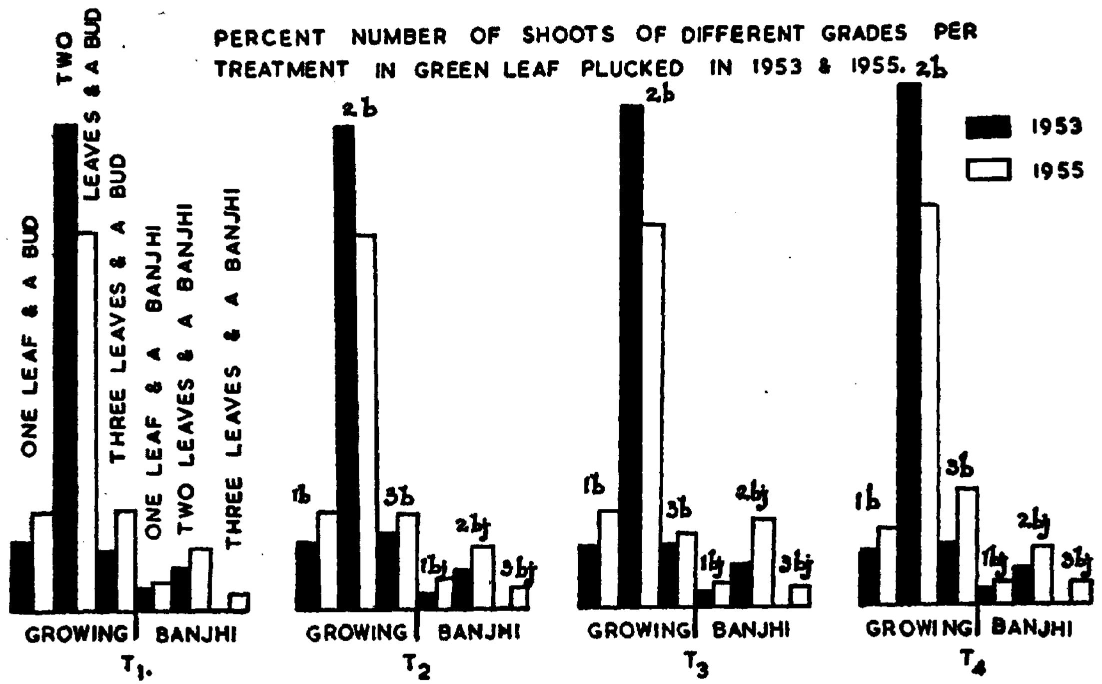
Table 15 : Yield in mds. made tea per acre.

Treatments	Yield
3	122.73
2	122.27
4	111.85
1	108.39

Critical Difference required at P=0.01 is 8.31 mds.

It is seen that the highest yields were obtained with those treatments where the tea was skiffed to level off once in three years and in the other two years pruned normally and the treatment where the tea was pruned only once in three years followed by a deep skiff and a levelling off skiff in the other two years.

Figure 5 : Kind of shoots in the plucked leaf from different treatments during 1953 and 1955.

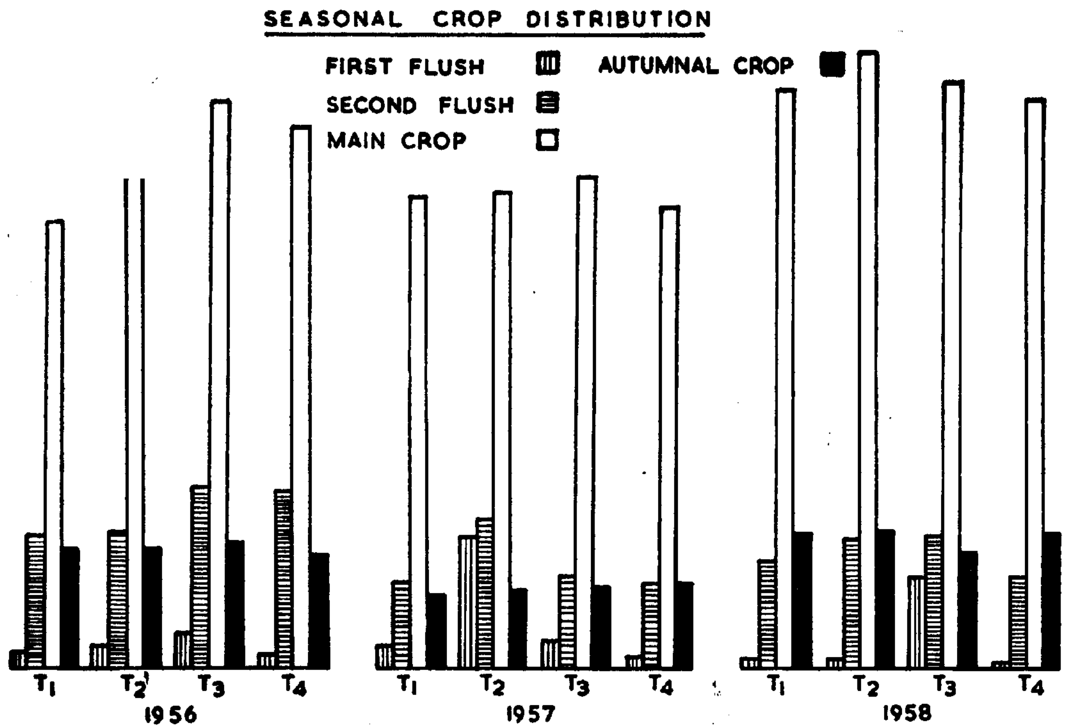


It is seen from *Figure 5* that the leaf plucked from the annually pruned plots contains a higher percentage of two and a bud shoots than the leaf plucked from the skiffed plots. The leaf plucked from the skiffed plots contains a higher percentage of single, double and treble banjhi shoots than the leaf from the annually pruned plots. It is known that banjhi shoots have lower quality and the presence of this larger percentage of banjhi shoots may be one of the contributory factors to the tendency of lower quality in the unpruned plots.

Seasonal Crop Distribution.— In order to demonstrate how the different methods of pruning affect the crop distribution, the yields during the different flush periods of the 3rd. cycle have been shown in *Figure 6*.

It is seen that in 1956, when the plots under all the treatments were pruned, the yield of leaf during the first flush period remained low in all the treatments but the yield of the second flush, main crop and autumnal crop remained high in all the treatments. In 1957, in the treatment where a heavy skiff was given (Tr. 1) the yield of first flush crop was low, but there was little difference in the yield of crop during the other flushes, compared to the annually pruned plots. The plots under Treatment 2 were skiffed to level off only and much higher yields were obtained from the first and second flush crops. Treatments 3 and 4 were both pruned in the normal manner and there was little difference in yield during the different flushes. In 1958, plots under Treatment 1 were skiffed $\frac{1}{2}''$ over the previous year's heavy skiffing level and the yield during the first flush was low and no different to that obtained from the annually pruned plots (Tr. 4). The yields during the other flushes also were not different from the annually pruned plots. In Treatment 2 where the plots were skiffed the yield during the first flush was only a little higher than that of the annually pruned plots but much higher yields were obtained during the second flush. In Treatment 3 where the plots were skiffed to level off, considerably higher yields were obtained during the first flush as was the case in Treatment 2 in 1957. There was, however, a tendency towards a somewhat reduced yield during the autumn flush (*Figure 6*).

Figure 6 : Seasonal Crop Distribution during 1956 and 1958.



Liquor and Dry Tea characters on Tasters' Reports.— The effects of the treatments on the liquor and dry tea characters, in the second cycle, have already been reported in the Annual Report for 1955 and it was reported that none of the treatments in any of the years of the previous cycle showed any significant difference in respect of quantity of tip, colour of tip, appearance of dry teas, colour of infused leaf, strength of liquor, quality, briskness and valuation.

In each of the three years of the third cycle also, representative samples of leaf from each of the four treatments were manufactured on a large scale, with the co-operation and assistance of the Senior Biochemist.

1956 :

This was the first year of the 3rd. cycle and the bushes of all the four treatments were pruned. The bushes of Treatments 1 and 2 were pruned on three year old wood, the bushes of Treatment 3 were pruned on two year old wood and the bushes of Treatment 4 were pruned on one year old wood.

The effects of the treatments were found to be significant ($P = 0.05$) in the quantity of tip and valuation of the teas made.

Quantity of Tip :—The amounts of tips in the different treatments as assessed by the Tocklai taster and a panel of tasters in Calcutta were as shown in *Table 16.*

Table 16 : Tasters' marks.

T_4	T_3	T_1	T_2	C.D.($P = 0.05$)
550	523	500	396	92

It shows that the younger the wood on which the bushes were pruned, the higher was the amount of tips in the made teas, although there was no significant difference between the teas made from Treatments 4, 3 and 1. It should, however, be realised that in Treatment 1, although the pruning was done on three year old wood, the operation given at the ends

of both the 2nd. and 3rd. years, was a very heavy skiff and can be almost termed a prune.

Valuation :—The average prices given in rupees by the Tocklai taster and the panel of tasters in Calcutta were as shown in *Table 17*.

Table 17 : Valuations in rupees.

T_4	T_2	T_3	T1	C.D.(P=0.05)
2.68	2.68	2.65	2.56	0.09

There was no significant difference between the values of the teas made from the Treatments 4, 2 and 3. The reason for the samples of Treatment 2 getting the same valuation as the sample of Treatment 4 was possibly the somewhat improved colour of liquor, colour of infused leaf and the strength of the teas of this sample.

1957 :

This was the second year of the third cycle and the bushes under Treatment 1 were very heavily skiffed and the bushes under Treatment 2 were skiffed to level off only. Bushes under Treatments 3 and 4 were pruned in the normal manner by leaving ½" of new wood.

Significant differences were found between the quantity of tips and valuation.

Quantity of Tip :—The amounts of tip in the teas made from the plots under the four different treatments as assessed by the Tocklai taster and the panel of tasters in Calcutta were as shown in *Table 18*.

Table 18 : Tasters' marks.

T_1	T_3	T_4	T_2	C.D. (P=0.05)
487	449	422	272	118

It is seen that the quantity of tips is the least in the teas made from the plots that were only skiffed to level off.

Valuation :—The average prices in rupees given by the Tocklai taster and the panel of tasters in Calcutta were as shown in *Table 19.*

Table 19 : Tasters' marks.

T_3	T_1	T_4	T_2	C.D. (P=0.05)
2.66	2.66	2.60	2.55	0.06

Here again the teas made from the lightly skiffed plots had a tendency to get the lowest valuation. The teas made from plots under Treatments 3 and 1 were valued at a significantly higher valuation and it can be seen that the teas made from the heavy skiffed or pruned plots were valued higher.

1958 :

This was the third year of the third cycle and plots under Treatment 2 were deep skiffed after levelling off skiff the previous year and the plots under Treatment 3 were skiffed to level off only. The plots under Treatment 1 were pruned ½″ over the previous year's heavy skiffing level and the plots under Treatment 4 were normally pruned.

As in previous years, the representative samples of leaf from the four treatments were manufactured in a large scale by the conventional method and the teas were tasted by the Tocklai taster and a panel of tasters in Calcutta. The scores given by the tasters were analysed and significant differences have been observed in many of the attributes.

Quantity of Tip :—The amounts of tip as assessed by the tasters were as shown in *Table 20.*

Table 20 : Tasters' marks.

T_1	T_4	T_3	T_2	C.D. (P=0.05)
41.6	38.8	31·9	27.6	8.2

It is seen that the teas made from plots that were deep skiffed after a levelling off skiff the previous year (T_1), produced significantly lower amount of tip than the teas that were

pruned (T_1 and T_4). Teas made from the plots that were skiffed to level off only for the first time in the cycle also had a tendency to produce less tip than the pruned plots.

Colour of Infused Leaf :—The tasters' assessments have been as shown in *Table 21.*

Table 21 : Tasters' marks.

T_4	T_1	T_3	T_2	C.D. (P=0.05)
49.4	41.1	38.3	36.7	7.4

It is quite apparent from the above figures that the brightest colours were obtained from the teas made from the plots that were annually pruned.

Quality :—The tasters' average scores for quality have been as shown in *Table 22.*

Table 22 : Tasters' marks.

T_4	T_3	T_2	T_1	C.D. (P=0.05)
50.0	46.7	42.2	38.3	7.4

Here also the teas from the annually pruned plots tended to have the highest quality and this was significantly higher than teas from Treatments 2 and 1.

Colour of Liquor :—The tasters' assessments have been as shown in *Table 23.*

Table 23 : Tasters' marks.

T_3	T_2	T_4	T_1	C.D. (P=0.05)
54.4	51.1	49.4	45.0	6.2

Here the colour of liquor of the teas made from the plots skiffed to level off only, produced brighter colour than the teas made from plots that were pruned over the heavy skiffing level of the previous year (T_1) and had a tendency to produce brighter colour than the teas made from the annually pruned plots.

Briskness.—The tasters' assessments of briskness did not show any significant differences, although there was a tendency for the teas made from annually pruned plots to have the most briskness as can be seen in *Table 24*.

Table 24 : Tasters' marks.

T_4	T_3	T_2	T_1	C.D. (P=0.05)
50.0	46.7	42.8	41.7	Not significant

Valuation :—The average valuations in rupees, given by the tasters were as shown in *Table 25*.

Table 25 : Tasters' marks.

T_4	T_3	T_2	T_1	C.D. (P=0.05)
2.96	2.89	2.86	2.81	Not significant

Here again, although there was a tendency for the teas made from the annually pruned plots to be valued higher, the differences were not significant.

Pest infestations.— Observations on Jassid and Red Spider infestations were taken in some of the years with the kind co-operation of the Senior Entomologist.

Jassids :

In the Annual Report 1955, it was reported that in 1953, *i.e.* in the first year of the second cycle when Treatments 1, 2 and 3 were pruned on to wood that was more than 1 year old all these treatments were attacked by jassids at a significantly higher rate than the plots under Treatment 4 which were annually pruned. Unfortunately no observations could be taken in 1956, but in 1957, although no significant differences in the intensity of jassid attack were observed, it was noticed that the plots that were skiffed to level off only were inclined to be least attacked by jassids. In 1958 the lightly skiffed plots were found to be most seriously attacked.

Observations on Red Spider infestations :

In 1955 it was found that the plots under Treatment 3, which were skiffed to level off only, had the highest incidence of Red Spider. The pruned and deep skiffed plots did not show any serious infestations. In 1957, however, the plots that were skiffed to level off only, did not show significantly higher intensity of Red Spider attack than the pruned plots. The heaviest infestations appeared in the plots that were pruned over the level of deep skiff the previous year.

From the various observations taken during the last six years, it does appear that when bushes were pruned after one or more of unpruned years, they were more susceptible to attacks by jassids and that the bushes that were not pruned in the normal manner but were skiffed in some manner or other, tended to suffer more from Red Spider attacks. The plots in question were small, and it is feared that if the skiffed areas were large, the Red Spider attacks would have been of a much greater intensity.

General :

Inspite of some increase in crop from skiffed plots as compared with pruned, the incidence of pests and the lowering of quality do not at present justify any change in the normal practice in the Assam Valley of an annual prune. In districts where the production of a high proportion of early season crop is of more economic importance, the potential lowering of quality of the whole season crop during the unpruned years, may be more than offset by the increased production of the early season crop from skiffed areas.

Severity of Plucking—Expt. No. B.20 :

This experiment has been running for 23 years, and was last reported in the Annual Report 1948, to which reference can be made.

This experiment was laid out in 1935 on a section of Rajghar tea planted at 4½ ft. triangular spacing in 1924 to study the effect of different systems of plucking of varying

severity on the yield and distribution of crop. The layout is of randomised block design with seven replications. Four of these replicates have received a lower level of nitrogen than the other three. Till 1945, the levels of nitrogen were 40 lbs. and 60 lbs. per acre respectively and from 1946, the levels have been increased to 60 lbs. and 120 lbs. per acre respectively.

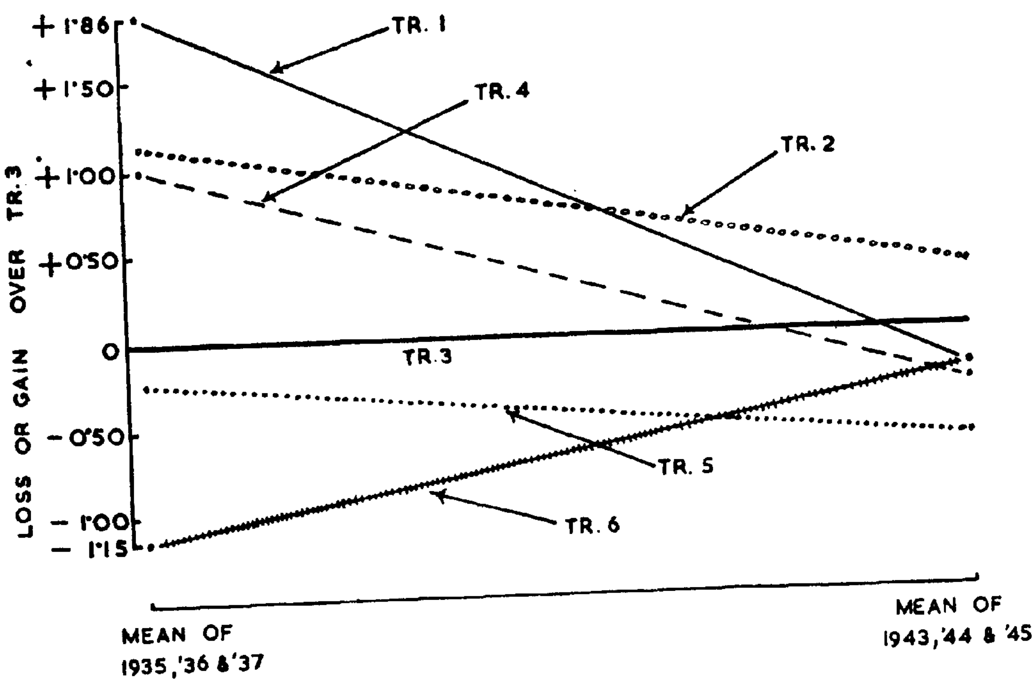
There are ten different plucking treatments in the experiment as a whole, but some of these treatments have been changed during the course of the past 24 years, and others have been omitted in certain years, particularly during the war, for administrative reasons. In order to avoid confusion, only such treatments as have remained entirely unchanged, and have never been discontinued at any time since their commencement, are being dealt with. This eliminates Treatments 7, 8, 9 and 10 and this report is confined to Treatments 1 to 6.

These six plucking treatments are as follows :—

1. Tip at 4″ and then pluck to janam.
2. Tip at 6″ and then pluck to janam.
3. Tip at 8″ and then pluck to janam.
4. Tip at 4″ and pluck to janam and then leave a leaf at end of second flush and pluck to janam.
5. Tip at 6″ and pluck to janam, then leave a leaf at end of second flush and pluck to janam.
6. Tip at 8″ and pluck to janam, then leave a leaf at end of second flush and pluck to janam.

Figure 7 shows the overall trend of each treatment for the mean level of 50 lbs. nitrogen per acre, for the period 1935 to 1945 inclusive, when only low levels of nitrogen were applied. These results have been plotted to show the yield of each treatment in relation to the yield from normal 8″ to janam (Tr. 3) plucking, which is plotted as a straight line. The average of the first three years and the last three years of the period only are plotted in the *figure*, to show the general trend of yield under various plucking treatments.

Figure 7 : Trend of yield of the different treatments in the mean level of 50 lbs. nitrogen per acre for the period 1935 to 1945.



During this period, 4″ to janam plucking (Tr. 1) gave the highest yield, but the loss of vigour under this treatment was so rapid that by the end of this period, this treatment was giving less yield than 8″ to janam plucking (Tr. 3), which treatment has been taken as the control for the purposes of this experiment.

Treatment 2 *i.e.* 6″ to janam also gave higher yields initially than the control (Tr. 3), but this showed a decline and would have finished up by giving less yield than the control after another 1 or 2 years, which it actually did by 1946. Treatment 4 with 4″, then a leaf plucking also gave similar results to that produced by 4″ to janam plucking (Tr. 1). The conclusion from these results is that under the conditions of the experiment, Treatments 1, 2 and 4 did not allow sufficient maintenance leaf to remain on the bushes to sustain the amount of crop harvested. Vigour was reduced thereby, with a compensatory drop in yield, and if such treatment persisted, the economic life of the bushes would be reduced.

During this period (1935-45), the two other treatments, 6″, then a leaf (Tr. 5) and 8″, then a leaf (Tr. 6) never yielded as much as the control (Tr. 3). The initial yield of Treatment 5 was lower, possibly because of leaving the leaf at the end of the 2nd. flush, at a height not suited to this jat of tea. The initial yield of Treatment 6 was lower, likely because of a very high level of plucking after the second flush. Yield of 6″, then a leaf plucking (Tr. 5) continued to be low with a downward trend throughout the period because of low initial tipping. Plucking to 8″, then leaving one leaf at the end of the 2nd. flush (Tr. 6) apparently built up the vigour of the bushes to a greater extent than the control (Tr. 3), but this level of plucking was so light that the harvested crop could not be equal to that from 8″ to janam (Tr. 3) plucking, and the very slight gain in vigour was thus not a practical proposition.

In 1946, nitrogen was increased to 60 lbs. and 120 lbs. per acre and as the difference between the two levels was high, the results obtained from the different methods of plucking are

being shown separately and are being compared with continuous 8″ to janam (Tr. 3) plucking. The tea got very high and hence, it was medium pruned at 26″ in December 1948. In 1949, all plots were plucked alike *i.e.* at 38″ and the treatments were re-applied from 1950.

Tables 26 and 27 show the annual yields from 1946 to 1958 of Treatments 1, 2, 4, 5 and 6 in comparison with 8″ to janam plucking (Tr. 3) in the two different levels of nitrogen.

It is seen from *Table 26* that when only 60 lbs. of nitrogen per acre has been applied since 1946, practically all the treatments have given nearly as high or a little higher yields than 8″ to janam plucking (Tr. 3) and the average annual increases obtained during the period 1946 to 1958 is shown in last column. However, it is seen that 4″, then a leaf plucking (Tr. 4) and 6″, then a leaf plucking (Tr. 5) have given higher yields than 4″ to janam (Tr. 1) and 6″ to janam (Tr. 2) pluckings. The yield obtained from 6″, then a leaf plucking (Tr. 5) was highest for this dose of nitrogen, but this yield has not been as high as that obtained from 8″ to janam plucking (Tr. 3) with the higher dose of nitrogen. The annual differences are shown in *Figure 8* and the total yield difference for the period is shown in *Figure 8a*. These results obtained with this particular jat of dark leaf tea, under Borbhetta conditions, may not, however, be generally applicable to other jats and under different conditions.

With the higher level of nitrogen *i.e.* (120 lbs.) without any shade, 8″ to janam plucking (Tr. 3), has given the highest yield, and the total loss in yield during the period due to other methods of plucking is shown in *Figure 9*. This and similar levels of nitrogen are more normally used and, therefore, these results are of wider application.

As has already been mentioned, the tea in this experiment has been without shade. If it was under shade, the gain in yield from 8″ to janam plucking, might have been even higher. In shaded tea, the highest yields may have been obtained even with the lower level of nitrogen.

Table 26 : Average Annual Gain or Loss in mds. made tea per acre from different plucking systems over 8" Janam plucking (Tr. 3) with 60 lbs. nitrogen per acre, during 13 years i.e. from 1946 to 1958.

Treatments \ Year	1946	1947	1948	*1949	1950	1951	1952	1953	1954	1955	1956	1957	1958	Average Loss or Gain per year
1	-0·49	-0·81	-0·72	+0·14	+0·81	0	-0·28	+0·63	+0·52	+0·96	+0·24	+0·60	-0·19	+0·10
2	+0·12	+0·38	+0·04	+0·28	-0·14	-0·65	-0·09	+0·05	+0·29	+0·82	+0·26	+0·68	+0·07	+0·16
4	-0·61	+0·94	-0·35	+0·34	+0·79	+0·17	+0·05	+1·19	+0·38	+1·41	+0·89	+1·39	-1·54	+0·38
5	-0·28	+1·06	-0·38	+0·12	+1·07	0	-0·12	+1·05	+1·19	+1·10	+0·77	+1·57	-1·31	+0·44
6	-0·56	+1·50	+0·54	+0·20	+2·45	+0·15	+0·30	+1·17	+0·01	+0·03	+0·35	+1·13	-2·40	+0·37

*Year of uniform treatment after medium prune.

Table 27 : Average Annual Gain or Loss in mds. made tea per acre from different plucking systems over 8" Janam plucking (Tr. 3) with 120 lbs. nitrogen per acre during 13 years i.e. from 1946 to 1958.

Year / Treatments	*1946	1947	1948	*1949	1950	1951	1952	1953	1954	1955	1956	1957	1958	Average Loss or Gain per year.
1	-0.21	-2.87	-2.66	-0.31	+0.11	+0.07	-0.84	-0.86	-0.58	-0.72	-0.60	-0.40	-1.60	-0·88
2	-2.43	-2.80	-1.33	-0.12	-2.24	+1.16	-0·72	-0.28	-0.58	+0.03	-0.18	-0.90	-0.95	-0.87
4	-0.84	-0.82	-2.45	+0.46	+0.53	+2.00	+0.47	+0.58	-0.88	+0.47	-0.25	+0.10	-2.40	-0.23
5	-1.03	-1.77	-2.54	+0.02	-2.36	-0.21	-2.85	-2.61	-3.15	-2.82	-2.51	-1.99	-4.89	-2.20
6	-0.29	-1.61	-3.03	+0.06	+0.16	+0.40	-0.89	-1·47	-2.12	-2.31	-1.23	-0.80	-3.89	-1.30

* Year of uniform treatment after medium prune.

Figures 8 and 8a : Annual yields of 8" to janam plucking with 120 lbs. nitrogen per acre and 6" to janam + 1 leaf in second flush with 60 lbs. nitrogen per acre.

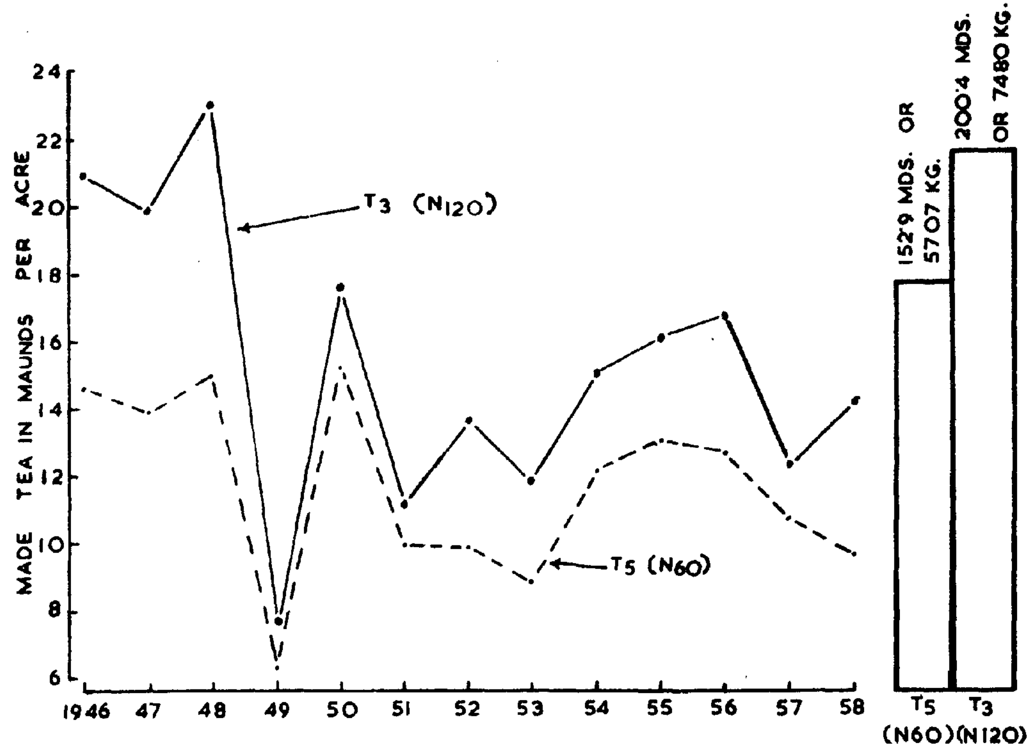
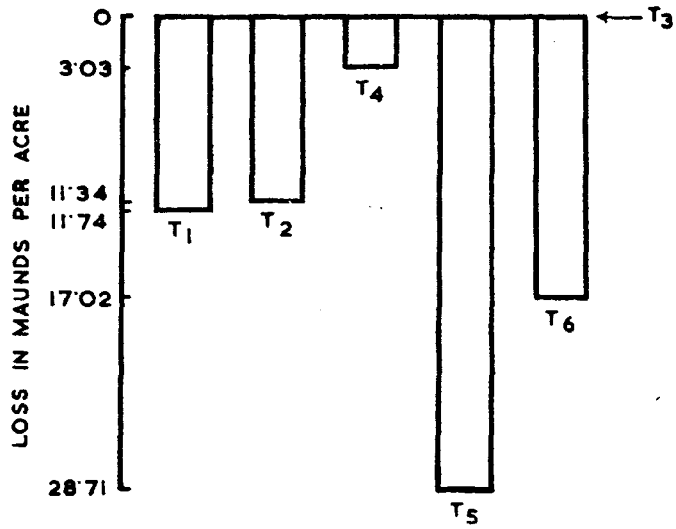


Figure 9 : Total loss of made tea in maunds per acre in 13 years from different plucking systems over 8" to janam plucking with 120 lbs. nitrogen per acre.



The general trend shown by the various plucking treatments of this experiment, supports our recommendation that tea in the plains should be plucked at 8″ to janam under all normal conditions.

Mechanical Harvesting—Expt. No. B.6.2 :

Mechanical harvesting trials have been running since 1954 and were last reported in the Annual Report for 1957. This experiment is also reported in the Engineering Branch Report.

The trial of the mechanical harvester was continued during 1958 in the same area of tea. This was planted in 1935 at 4 ft. × 4 ft. square spacing and is without shade. Machine and hand plucking treatments were applied to the same plots as before but with some modifications. The treatments in 1958 were as follows :

A. Hand pruned by leaving ½″ of new wood and cleaned out by knife. Hand plucked—tipped at 8″ and plucked to the janam on a 7 day round.

B. Mechanically pruned by leaving $\frac{1}{2}''$ of new wood and cleaned out by knife.

Mechanically harvested. Tipped at 6″ and raised by $\frac{1}{4}''$ in each round. Frequency of harvesting was determined by the growth and was on an average on a 10 day round.

C. Mechanically pruned by leaving $\frac{1}{2}''$ of new wood and cleaned out by knife.

Mechanically harvested. Tipped at 4″ and raised by $\frac{1}{4}''$ in each round Plucked on the same day as Treatment B.

The layout was in randomised blocks with 8 replications, each plot having 100 bushes in one row.

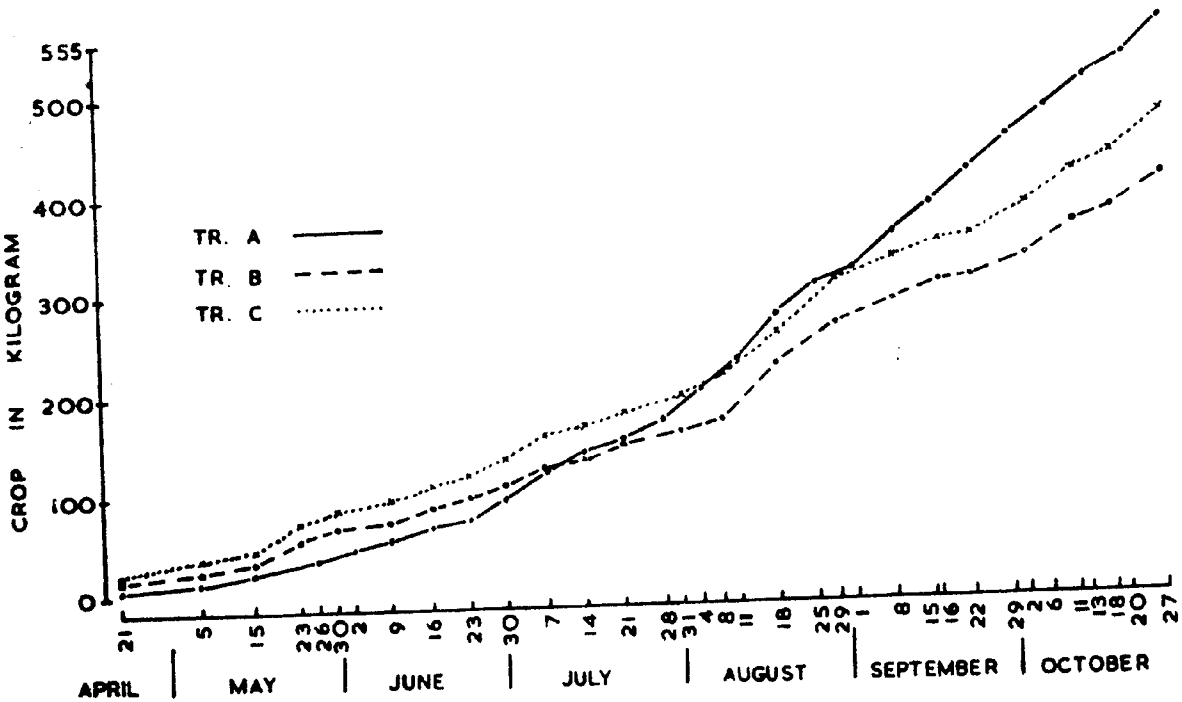
Hand plucking (Treatment A) produced significantly higher yield as compared to both the mechanically harvested treatments (Treatments B and C). Between both the mechanically harvested treatments, Treatment C where the tea was tipped at 4″ and raised by $\frac{1}{4}''$ in each round, yielded significantly higher than the Treatment B where the tea was tipped at 6″ and raised by $\frac{1}{4}''$ in each round, yielded significantly higher than the Treatment B where the tea was tipped at 6″ and raised by $\frac{1}{4}''$ in each round (*Table 28*).

Table 28 : Yield of made tea per acre under different treatments.

	Hand Plucking A	Mechanical harvesting B	Mechanical harvesting C	C. D. at 5% level
Yield in mds. ...	12.31	8.63	9.95	1.23

Plucking of tea started from 21st April, 1958. From *Figure 10* it is evident that both the mechanically harvested treatments produced higher yields in the early season crop. But Treatment A started producing more crop over Treatment B from 7th July and over Treatment C from 8th August. This rise in the main season crop in Treatment A over the mechanically harvested treatments was the reason for its superiority over Treatment B and C

Figure 10 : Cumulative weekly yields in kilograms of the 3 different treatments.



There was a certain amount of unmanufacturable coarse leaf in the mechanically harvested treatments. This is shown in *Figure 11* in the form of percentage crop distribution in different grades of plucked leaf.

Comparing the grades of plucked leaf harvested in 1958 with those harvested in 1957 (see last year's report, page 103) it is obvious that from this point of view a lower tipping level with regular rise in plucking height may be preferable for mechanical harvesting.

Trial of Dalapon Weedicide—Expt. No. B.33.2B :

This is a short term experiment which has not been previously reported.

The object of the experiment was to observe the effects of different doses of Dalapon ('Dowpon' of Messrs. Dow Chemical Company, Ltd.) on the weeds (specially thatch grass —*Imperata* species) in young tea.

The experiment was conducted in light leaf Assam jat of tea planted at 4½ ft. × 4½ ft. triangular in 1951, and was started in 1958 with the following treatments :—

(1) Check.

(2) 4 lbs. Dalapon per acre.

(3) 8 lbs. Dalapon per acre.

(4) 12 lbs. Dalapon per acre.

(5) 4 lbs. + 4 lbs. + 4 lbs. Dalapon per acre in 3 sprayings at monthly intervals.

(6) 16 lbs. Dalapon per acre.

(7) 6 lbs. + 5 lbs. + 5 lbs. Dalapon per acre in 3 sprayings at monthly intervals.

(8) One cheeling only.

First spraying was done on 21st May, 1958 when the ground was covered with broad-leafed weeds and thatch grass. The layout was in randomised blocks with 3 replications.

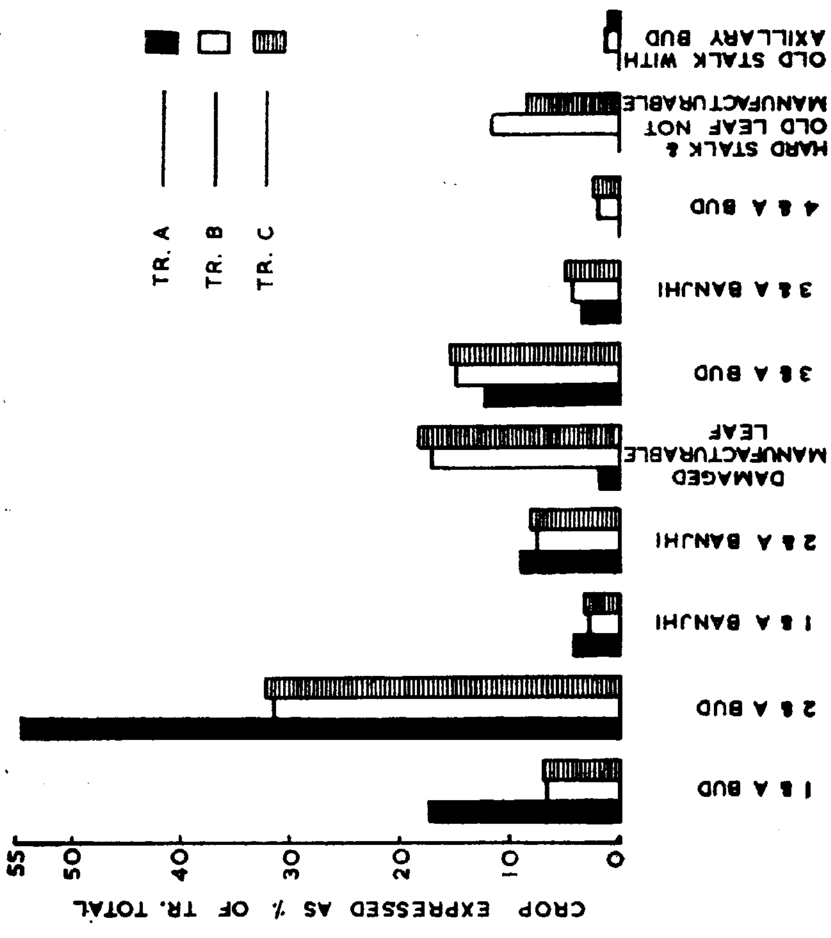


Figure 11 : Percentage of crop distribution in different grades of plucked leaf under different treatments.

Dalapon was sprayed with 40 gallons of water per acre in a low volume spray so that it completely covered the grass without reaching the run off point.

Three weeks after the spray, observations were made on the number of bushes damaged by the chemical. A significantly larger number of bushes was affected in plots which received Dalapon at the rate of 12 lbs. and 16 lbs. per acre than in plots receiving lower dosages. In the highest dose about 90% bushes were affected.

Table 29 : Average number of bushes per plot detrimentally affected.

	Tr. 1	Tr. 2	Tr. 3	Tr. 4	Tr. 5	Tr. 6	Tr. 7	Tr. 8
Average number of bushes ...	0	2.3	2.7	6.7	2.0	9	2.0	0
Percent affected bushes ...	—	23	27	67	20	90	20	0

Critical Difference at 5% between the chemical sprayed plot = 2·8

Observations showed that Dalapon was effective in controlling the thatch grass. The doses above 8 lbs. Dalapon per acre produced pronounced scortching of the leaves, particularly of the tender shoots. In the third week of December, a visual score on the growth of the thatch grass was made. *Table 30* gives the average score in a descending order, of the different treatments. The higher the score, the more is the total growth of thatch.

Table 30 : Scores on growth of Thatch.

Treatment No.	Average visual scores.
1	60
4	57
3	53
6	42
2	37
8	32
7	30
5	28

The differences between the three treatments as regards the length of the roots were not significant but there was a tendency in Group II plants to produce longer shoots. The length of roots in Group III plants was shortest (*Table 33*). The percentage of survival was also highest in Group II and lowest in Group III.

Table 33 : Mean length of roots per plant in inches and survival percentage in the three Groups.

	Group I	Group II	Group III
	Normal propagation	Propagation in "Alkathene" film tubes—bottom open.	Propagation in "Alkathene" lay flats—bottom sealed and having one hole.
Mean length of roots in inches	6.8	8.2	5.6
Survival percentage ...	88	96	76

The experiment is being repeated with larger number of cuttings and also with seed.

Manuring of Bamboos—Expt. No. B.9A :

This experiment was last reported in the 1957 Annual Report, to which reference can be made.

The object of the experiment was to study the effect of different combinations of nitrogen, phosphate and potash on the growth of bamboos which is a very important subsidiary crop for most tea estates. The trial was started in July 1955 on young bamboo plants planted early in 1954. There were 4 treatments and 5 replications thus making 20 plots in all, each of which represented a bamboo clump. The preliminary observations on height and number of tillers of each clump were taken in early July, 1955. The fertiliser mixtures were applied in a circle of 10 feet diameter during 1955 to 1957 whereas in 1958 mixtures were applied in a circle of 12 feet diameter. The treatment ratios and the actual amounts applied are shown in *Table 34*.

Table 34 : Manuring of Bamboo—Treatments.

Treatments	Sulphate of Ammonia in lbs.			Superphosphate in lbs.			Sulphate of Potash in lbs.			Total in lbs.			Ratio of N. P. K.		
	1955 & 1956	1957	1958	1955 & 1956	1957	1958	1955 & 1956	1957	1958	1955 & 1956	1957	1958	N	P_2O_5	K_2O
1	$1\frac{1}{8}$	3	4	$\frac{3}{8}$	$\frac{3}{4}$	1	$\frac{3}{8}$	$\frac{3}{4}$	1	2.0	$4\frac{1}{2}$	6	4	1	$2\frac{1}{2}$
2	$1\frac{1}{8}$	3	4	—	—	—	$\frac{3}{8}$	$\frac{3}{4}$	1	$1\frac{5}{8}$	$3\frac{3}{4}$	5	4	0	$2\frac{1}{2}$
3	$1\frac{1}{8}$	3	4	$\frac{3}{8}$	$\frac{3}{4}$	1	—	—	—	$1\frac{2}{3}$	$3\frac{3}{4}$	5	4	1	0
4 (Check)	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—

(Note : Due to typographical errors some wrong figures appeared in the Annual Report 1957—Table 31.)

Height.— *1955* :—Treatment 3 (N.P.) significantly increased the height as compared to Treatment 4 (Check). The differences in height between the Treatments 3, 2 and 1 and 2, 1 and 4 were not significant.

1956 :—Treatment 3 (N.P.) significantly increased the height over Treatment 1 (N.P.K.) and 4 (Check). The differences between Treatments 2 and 1 were not significant.

1957 :—Treatments 3, 1 and 2 significantly increased the height when compared to Treatment 4 (Check) but failed to produce any significant difference among themselves.

Table 35 : Mean adjusted height and number of Tillers

Treatments	Mean adjusted height in feet				Mean adjusted number of Tillers			
	1955	1956	1957	1958	1955	1956	1957	1958
1 (N. P. K.) ...	17.4	24.7	40.8	53.2	3.6	7.2	14.4	21.4
2 (N. K.) ...	17.6	29.6	40.5	55.0	3.2	8.0	15.0	22.6
3 (N. P.) ...	20.4	31.4	42.5	50.4	4.6	9.8	19.2	26.6
4 (Check) ...	15.3	20.9	32.2	42.0	2.8	5.2	10.2	14.4
C. D. at 5% level ...	3.26	5.33	7.6	6.43	—	2.78	5.1	5.7

Table 36 : Percentage of increase in height and number of Tillers due to manuring over no manure.

Treatments	% Increase in height				% Increase in no. of Tillers.			
	1955	1956	1957	1958	1955	1956	1957	1958
1 (N.P.K.) ...	13.5	18.3	26.7	26.6	28.6	38.4	41.2	48.6
2 (N.K.) ...	14.6	41.8	25.8	30.9	14.3	54.0	47.1	56.9
3 (N.P.) ...	33.0	50.4	32 0	20.0	64.3	88.4	88.2	84.7

1958 :—Treatments 2, 1 and 3 produced significantly taller bamboos as compared to Treatment 4 (Check) whereas there was no significant difference in height between them.

In all the four years, Treatment 3 (N. P.) produced significantly taller culms than Treatment 4 (Check) and in 3 years N. and P. combinations produced the tallest bamboos (*Table 35*).

Tillers: *1955* :—Although no significant differences were obtained between different treatments in this first year, Treatment 3 (N.P.) had the tendency to produce larger number of tillers (*Table 35*).

1956 :—Treatments 3 (N.P.) and 2 (N.K.) produced significantly larger number of tillers than Treatment 4 (Check). There was no significant difference between the Treatments 3, 2 and 1.

1957 :—Only Treatment 3 (N.P.) produced significantly larger number of tillers than Treatment 4 (Check). There were no significant differences between Treatments 3, 2 and 1 and 2, 1 and 4.

1958 :—Treatments 3, 2 and 1 produced significantly larger number of tillers as compared to Treatment 4 (Check).

In each of the four years, Treatment 3 (N.P.) produced the largest number of tillers and these differences were significant over the Check in 3 years (*Table 35*). The percentage increase in heights and the number of tillers, due to manuring, is shown in *Table 36*.

From the results of the 4 years under the experimental conditions it can be concluded that a mixture of sulphate of ammonia and superphosphate in the ratio of 4 : 1 (N : P_2O_5 : 4 : 1) was beneficial for the growth and development of young bamboos.

By the end of 1958, the clumps had attained reasonable heights and the future effects are more likely to be on the number of tillers and possibly on the girth of the bamboos. The experiment will be continued, in order to observe the effects of the treatments on the mature clumps.

SCIENTIFIC PUBLICATIONS

The following two papers have been accepted for publication by the Empire Journal of Experimental Agriculture :—

(*a*) "Manuring of Green Crops used in Tea Culture" —jointly with Agronomist, Dr. K. N. Sharma.

(*b*) "Size, Shape and Number of Plots for Field Experiments with Tea."

—jointly with the Senior Advisory Officer, Cachar, Mr. E. D. Heath.

ADVISORY

Correspondence.— 511 letters were written by this branch, out of which 199 were in answer to queries on technical matters.

Touring.— The Senior Agriculturist visited 14 gardens in Dooars and Assam. The Assistant Agriculturist visited 16 gardens in Darjeeling and Assam. The Agronomist visited 18 gardens in Assam.

Meetings.— The Tocklai Annual Conference was attended by all the three Officers of the Branch.

Lectures.— The Senior Agriculturist gave a lecture on "Manurial Requirements of Tea in Assam" to the Assam Agricultural Science Society on 23rd. December, 1958.

Courses.— The Senior Agriculturist ran two lecture courses on Vegetative Propagation in November, 1958.

Publications.— The following Tea Encyclopaedia Serials were published by the Senior Agriculturist :—

Serial No. 9/3 THE MANURING OF YOUNG TEA.
—jointly with the Senior Advisory Officer, Assam and the Agronomist.

Serial No. 120 PADDY CULTIVATION.

BORBHETTA EXPERIMENTAL ESTATE REPORT

Labour.— The average daily attendance during the year was 438.

Crop Yield.— The total yield of green leaf during the year compared with that of 1957 was as follows :—

1957	...	...	2,49,403 lbs.
1958	...	...	2,53,400 lbs.

Of the 1958 crop, 2,24,806 lbs. were sold to Messrs. Jorehaut Tea Co., Ltd. General plucking was stopped from the 18th November, 1958.

Buildings.— The following were built :—

(*a*) Ten pucca labour quarters.

(*b*) One Godown.

(*c*) Extension to the Detention Ward.

(*d*) Cook House in Field Assistant's quarter.

(*e*) Extension to the Office.

(*f*) The office has been re-roofed.

(*g*) Power House.

Lands.— $1\frac{3}{4}$ acres of land were purchased during 1958. This brings the total of new lands purchased since 1955 to approximately $29\frac{1}{4}$ acres only and the need for new land still remains urgent.

Meteorological Observations.— The following table shows the results of the meteorological observations taken at Borbhetta during 1958 :—

Table 37 :

Month	Mean Temperature °F		Rainfall in inches	No. of rainy days.
	Maximum	Minimum		
January	72.8	52.4	0.36	6
February	72.0	55.6	1.58	10
March	86.0	60.3	0.40	5
April	85.0	68.5	4.61	19
May	81.5	72·0	14.12	24
June	90.6	78.3	7.60	19
July	89.6	77.7	24.75	30
August	86.7	77.0	12.73	30
September	89.5	77.5	4.43	13
October	84·8	72.7	5.90	14
November	81.2	60.8	0.01	1
December	72.7	55.5	1.57	5
Total			78.06	176
Average	82.7	67.4		

APPENDIX A.

List of Experiments Conducted by the Agricultural Branch at Borbhetta.

The same serial numbers as last year are retained for reference. Serial numbers of experiments which have been stopped are bracketed.

Long Term Experiments:

Serial Nos.	Subject of Experiments	Area Nos.
1.	N.P.K. Manuring of Mature Tea ...	11/2
2.	N.P.K. Manuring of Mature Tea with six combinations in divided doses	43
3.	N.P.K. Manuring on Light and Dark Leaf Jats of Tea	7
4.	N.P.K. Manuring of Young Assam and China Jats	25/27
5.	N.P.K. Manuring of Tea Seed Bari ...	4/1
6.	Trial of New Shade Trees (12 species) ...	101
7.	Trial of New Shade Trees (16 species and No shade)	102
8.	Trial of New Shade Trees (7 species and No shade)	32.2
9.	Species of Shade Trees and P. K. Manuring ...	1A
10.	Shade and N.P.K. Manuring	5
11.	Shade and P.K. Manuring	40
12.	Density of Shade (With closeness of shade trees) in relation to Nitrogen Manuring ...	2A
13.	Density of Shade (3 light intensities) in relation to different doses and forms of nitrogenous manures	8.1/3

Serial Nos.	Subject of Experiments.	Area Nos.
14.	Relationship of Jat, Shade and Nitrogen ...	45/47
15.	Periodicity of Shade	34.1/3
16.	Annual Vs. Biennial Prune	5A
17.	Pruning Cycles	22.1
18.	Height of Plucking	20
19.	Spacing of Tea (5 spacings)	29.4
20.	Spacing of Tea (2 spacings, 2 clones and 4 levels of manure)	12.2
21.	Spacing in planting of two jats with doses of Nitrogen	104
22.	Agricultural Trials of Clones with different manures	33.2A
23.	Pruning Cycles	15/1.1
24.	Pruning of Young Tea	106/1

Short Term Experiments:

Serial Nos.	Subject of Experiments	Area Nos.	Term of Experiments
1.	Types of Nitrogenous fertiliser ...	28.1	5 years
(2).	Type of Phosphatic fertiliser in Mature Tea	15/1	1 year
3.	Type of Phosphatic fertiliser on Young Tea	44B/1	3 years
4.	Trial with Urea	15/2	3 ,,
5.	Time of Pruning	33.2C	3 ,,
6.	Debudding and Skiffing in Nursery	103/B	2 ,,
7.	Time and Method of Cleaning Out	43A.1	3 ,,

Serial Nos.	Subject of Experiments	Area Nos.	Term of Experiments
8.	Mechanical Plucking	6.2	4 years
(9).	Method of Planting and Manuring	49 A	2 ,,
10.	Introduction of new Shade Trees	45 & 100	3 ,,
11.	Introduction of new Green Crops ...	24 & 26	3 ,,
12.	Manuring of Green Crop and after effect on Tea	103	3 ,,
13.	Effect of Green Manures on Eel-worm Populations	43D.1/2	2 ,,
14.	Varying doses of Nitrogen with and without Phosphate at the time of planting	44B/3	2 ,,
15.	Time and Method of Cleaning Out ...	42C	3 ,,
16.	Trial of "Dalapon" weedicide ...	33.2B	3 ,,
17.	Rockphosphate Trial	2B.1	2 ,,
18.	Phosphating of Green Crop and Tea	43 C	3 ,,

Demonstration Plots:

	Pruning of Tea in Nurseries ...	19A/2
	Time and Method of Planting Out ...	41
	Method and Time of Planting Out	9C/14
	Type and Amount of Cultivation ...	25A
	Type and Amount of Cultivation ...	34.1
	Pruning Severity and Cleaning Out	28

APPENDIX B

List of Agricultural Experiments being conducted outside Tocklai.

Serial Nos.	Experiments	Gardens
Assam— North Bank		
1.	Multilevel N.P.K. experiment ...	Borjuli
2.	Experiment with different levels of Sulphate of Ammonia, Urea and Ammonium Chloride ...	Moinajuli
3.	Experiment with different levels of Sulphate of Ammonia, Urea and Ammonium Chloride ...	Pertabghur
4.	Organic Vs. Inorganic manure ...	Halem
5.	Cultivation experiment ...	Halem
Assam— South Bank :		
1.	Shade Vs. Manure ...	Hunwal
2.	Manuring experiment ...	Jamirah
3.	Multilevel N.P.K. experiment on Mature tea ...	Panitola
4.	Multilevel N.P.K. experiment on Young tea	Panitola
5.	Multilevel N.P.K. experiment ...	Murmuria
6.	Multilevel N.P.K. experiment ...	Margherita
7.	Multilevel N.P.K. experiment ...	Khoomtai
8.	Experiment with different levels of Sulphate of Ammonia, Urea and Ammonium Chloride ...	Murmuria Section 22.

Serial Nos.	Experiments	Gardens
9.	Experiment with different levels of Sulphate of Ammonia, Urea and ,Ammonium Chloride	Murmuria Section 3A.B
10.	Manuring under Shade Trees ...	Ducklingia
11.	Pruning Cycle experiment ...	Cinnamara
12.	Pruning Cycle experiment ...	Ducklingia
13.	Debudding experiment ...	Sealkotee
14.	Spacing experiment ...	Panitola
Cachar		
1.	N.P.K. Manuring experiment ...	Bhubandhar
2.	N.P.K. Manuring experiment ...	Pathini
3.	Nitrogen Manuring in Single and Divided doses	Silcoorie (Rani Teela)
4.	Rani Seed Bari experiment ...	Silcoorie
5.	Multilevel N.P.K. experiment ...	Roopacherra
6.	Pruning Cycle experiment ...	West Jalinga
7.	Pruning Cycle experiment ...	Burnie Braes
8.	Pruning Cycle experiment ...	Aenakhal
9.	Five year Pruning Cycle experiment on young tea by five different method of pruning	Silcoorie (Plot No. 2 C.A.B.)
10.	Five year Pruning Cycle experiment on young tea by five different method of pruning	Silcoorie (Plot No. 5 C.A.B.)

Serial Nos.	Experiments		Gardens
11.	District Clonal Trial (Teela layout)		Silcoorie
12.	District Clonal Trial (Flat layout)		Silcoorie
Dooars			
1.	Multilevel N.P.K. experiment	..	Kalchini
2.	Multilevel N.P.K. experiment	..	Ghatia
3.	Four levels Nitrogen manuring experiment ...	...	Baradighi
4.	Cultivation experiment	...	Kalchini
5.	Cultivation experiment	...	Bhatpara
6.	Cultivation experiment	...	Chuapara
7.	Pruning Cycle experiment	...	Chuapara
8.	Pruning Cycle experiment	...	Baradighi
9.	Times of Pruning experiment	...	Central Dooars
10.	Times of Pruning experiment	...	Chuapara
11.	Times of Pruning experiment	...	Bhogotpore
12.	Shade Tree experiment	...	Nye Sylee
13.	District Clonal Trial (No 3)	...	Nagrapata
14.	District Clonal Trial (No. 4)	...	Chuapara
15.	Pruning Vs. Red Rust	...	Nye Sylee
Darjeeling			
1.	N.P.K. Manuring experiment	...	Margaret's Hope
2.	Multilevel N.P.K. experiment	...	Rungneet
3.	Four levels Nitrogen Manuring experiment ...	...	Happy Valley

Serial Nos.	Experiments	Gardens
4.	Four levels of Nitrogen Manuring experiment	Singell
5.	Four levels of Nitrogen Manuring experiment	Happy Valley
6.	Nitrogen Manuring in Single and Divided doses	Salimbong
7.	Pruning Cycle experiment (Biennial, Triennial and Quadrennial pruning)	Mim
8.	Pruning Cycle experiment (Biennial, Triennial and Quadrennial pruning)	Mim
9.	Annual Vs. Biennial pruning ...	Nagri Farm
10.	Pruning Cycle experiment as in (7) and (8)	Nagri Farm
11.	Monthly Pruning experiment ...	Puttabong

PLANT PATHOLOGY BRANCH—ENTOMOLOGICAL SECTION

G. M. DAS—Senior Entomologist

STAFF

The Senior Entomologist was on overseas study leave from 29th June to 24th October and during this period he visited a number of Agricultural Research Institutes to acquaint himself with the recent developments in pest control. He also worked in the British Natural History Museum and consulted literature in connection with the preparation of three technical papers.

Sri Badan Chandra Barua joined this Branch as Junior Technical Assistant and Sri Nirmal Kumar Chakrabarty as Survey Assistant.

RESEARCH AND EXPERIMENT

PESTS OF TEA

Red spider mite: (*Oligonychus coffeae* Nietner):

Life history.— Studies on the pre-oviposition and oviposition periods and fecundity of fertilised females were made during the period from March to August, and the results have been presented in a paper*.

Occurrence of Red spider mite on tea bushes during cold weather.— Our recent observations confirm the view (Das*) that the red spider mite persists on tea bushes during the cold weather, in a lesser degree on cleaned out tea and in a greater degree on skiffed tea. It is also quite prevalent on young tea. These populations are primarily responsible for the damage in the spring. Counts of red spider population persisting on mature tea bushes during the cold weather were made—(1) after plucking was over but before pruning, (2) after pruning but

*Das, G. M.,—"Bionomics of the Tea Red spider mite (*Oligonychus coffeae* Nietner.), Bull. ent. Res. (Press)".

before cleaning out, and (3) after cleaning out. Twenty-five bushes were examined in 5 groups of 5 each, in Assam tea as well as China tea.

Table 1 : Persistence of red spider mite on tea bushes during cold weather.

Borbhetta—area 25/27.

Dates of treatment and observations.	Kinds of tea	Average number of leaves including 'janams' per bush.	Average number of infested leaves including 'janams' per bush.	Average number* of mites and eggs per bush
(i) *Before pruning.*				
Last plucking— 17-11-58				
Observations on Assam tea— 1—3-12-58	Assam	477.1	56.1 (18.7 janams)	779.2
Observations on China tea — 4 6-12 58	China	501.6	79.9 (14.3 „)	1778.5
(ii) *After pruning but before cleaning out.*				
Pruning— 13–16-12-58				
Observations on Assam tea— 23—26-12-58	Assam	134.2	22.7 (4.4 janams)	296.4
Observations on China tea— 26—27-12-58	China	275.0	48.0 (5.8 „)	634.1
(iii) *After cleaning out.*				
Cleaning out— 20-1-59	Assam	29.6	7.2 (0.6 janams)	167.7
Observations—21—24-1-59	China	45.9	6.8 (0.1 „)	255.0

* The increase of the mite population between observations has been taken into consideration.

It is evident from the above table that not only the old leaves but also 'janams' harbour the red spider mite in all stages of its development during the cold weather. The population of mites was, however, more than double on China bushes with more leaves on them than on Assam bushes before pruning, there being on an average 779.2 individuals including eggs per bush on Assam and 1,778.5 individuals per bush on

China type. After pruning, the population was reduced to 296.4 individuals per Assam bush and 634.1 individuals per China bush, while by cleaning out, it was further reduced to 167.7 individuals per Assam bush and 255.0 individuals per China bush.

It is, therefore, obvious that the mite population persisting on unpruned or skiffed tea is far more than that on pruned tea. With the cleaning out, there is further reduction in mite population, as many of the old leaves harbouring mites are removed from bushes.

In areas which are subject to severe red spider attack, complete defoliation of pruned tea is resorted to, as a measure against red spider attack. Such areas have been found to be almost free from red spider mite in the spring, unless there is mass migration from adjoining heavily infested areas. It is well known that dispersal of mites is effected by various means, and there is a possibility of mites being transported to the defoliated areas, but their number is not likely to be such as to cause a heavy build up in the spring.

In defoliation, those mites persisting on clean pruned tea are almost completely removed from bushes. Most of them, thrown on pruning litter, perish, while the very few that might climb up the bushes can hardly establish themselves thereon, if defoliation has been carried out before bud-break. Defoliation, therefore, appears to be a safe-guard against red spider attack. Young infills which are not defoliated are, however, focal points for spread of the mite, and it is customary to spray these infills during the cold weather.

It appears that if the red spider population persisting on bushes can be killed by spraying with acaricides in December or January, there is no reason why cold weather spraying should not be a safe-guard, just as is defoliation, against red spider attack in the spring.

Five field experiments with certain acaricides as a prophylactic measure against red spider have already been carried out

by this Section and the Pesticide Testing Unit during the cold weather, and a large number of simple prophylactic field trials are being carried out in different districts with varying climatic conditions.

It may be mentioned in this connection that there is a limitation in the choice of pesticides for use on tea, particularly during the plucking season. At present many of the persistent acaricides known to be effective against red spider cannot be used on plucking tea as the risk of health to consumers is involved. If these prophylactic trials prove successful, the question of toxic residues in made tea will not arise. Besides, it will be much easier to control red spider on pruned bushes having little foliage during the cold weather, and the dosage rate of acaricides and the cost of application will also be much reduced.

Red spider on Road-side bushes.—It is well known that dust covered road-side bushes are subject to serious attacks of red spider. This may be due to the following reasons:

(1) More laterals are left unpruned for extension of the frame on these bushes; obviously they carry more old leaves and consequently more mites on them during the cold weather.

(2) Occurrence of predators is less on the dust covered bushes.

(3) Stimulating effect of inert materials inducing increased multiplication of the mite.

Fleschner* (1956) recorded higher population of mites on the terminals (of Valencia orange) treated with inert materials such as talc, road-dust and zinc-deficiency spray material, and this increase was due to a direct stimulating effect of inert residues on mites. According to Holloway *et al*** (1942) the

*Fleschner, C. A. (1956) Field Approach to Population Studies of Tetranichid mites on Citrus and Avocado in California—Proc. Tenth Int. Cong. Ent. Vol. 2 : 669–674.

**Holloway, J. K., C. F. Henderson and H. V. McBurnie (1942). Population increase of Citrus Red mite Associated with use of Spray containing inert Granular residues. Jour. Econ. Ent. 35(3): 348-50.

Table 2 : Population of red spider mite on road-side bushes as compared to that on inner rows, in December.

Row number from the road-side	Average no. of side dals per bush.	Average no. of leaves including 'janams' per bush.	Average no. of infested leaves including 'janams' per bush.	Average no. of mites per infested leaf.	Average no. of eggs per infested leaf.	Average no. of mites and eggs per bush.
(i) *After pruning but before cleaning out.*						
1st	12.4	260.4	18.6	15.4	16 5	591.8
2nd	8.7	180.4	12 6	9.9	13.2	291.5
3rd	8.2	148 0	11.5	8.0	11.0	216.0
10th	8.0	116.2	11.6	5.5	9.5	174.8
12th	8.3	107.0	12.0	5.4	8.0	158.7
(ii) *After cleaning out.*						
1st	9.8	71.8	10.1	10.9	11.7	224.4
2nd	8.2	58.4	7.8	8.0	9.6	137.3
3rd	7.9	52.4	7.9	6.9	8.4	129.5
10th	7.7	57.8	7.8	6.3	8.5	115.0
12th	7.7	55.5	8.1	7.9	7.7	126.3

increase of citrus red mite associated "with the use of inert spray materials was due to the characteristics of the materials, not to influences on biological control factors".

The use of inert deposit to induce rapid development of mites in insectary mass-production for experimental work is stated to be a regular feature now-a-days.

In this connection it may be mentioned that the effect of use of pesticides as dusts which carry more inert material than in the wettable powder formulations for sprays on the red spider has to be critically examined and work on this aspect has already been taken up.

Prophylactic measures.— Two field trials were carried out at Borbhetta with Aramite, AKAR, malathion and malathion + Ovotran as a prophylactic measure against red spider mite. The incidence of red spider was, however, negligible and there was no significant difference in the degree of attack between the treatments and check.

Control.— A field trial was carried at Tocklai with Tetram, formerly known as R 6199, at different concentrations of 10 ppm, 20 ppm and 40 ppm along with lime sulphur at 1 in 40 parts of water. Tetram in all concentrations, as well as lime sulphur gave significant reduction of the red spider population over check, but the former at 10 ppm was found to be inferior to lime-sulphur.

Purple mite ((*Calacarus carinatus* Green):

Incidence.— Studies on the incidence of the purple mite on different kinds of tea were made from 50 mature leaves selected at random from a number of bushes at Tocklai in the month of April.

Table 3 : Comparative population of purple mite on Assam, China hybrid and China teas.

Kind of Tea	Total number of mites present on 50 leaves.	Average number of mites per leaf.
Assam	15298	306.0
China hybrid	3049	61.0
China	572	11.4

From the results it is evident that the Assam tea is more attacked than the China hybrids, the China plants being least attacked.

The mite, however, prefers older leaves and the degree of its incidence varies with the age of the leaves. Old leaves are more attacked than young leaves, the population of the mite

(adults and nymphs), being 15,298 individuals on 50 old leaves and 8,790 on 50 young leaves of Assam tea.

In the early stage of attack, the mites are found to be in almost equal number on both surfaces; but on heavily infested leaves, the population is more on the upper surface, there being 13,340 mites on the upper as against 1958 mites on the under surface of 50 mature leaves.

Control.— To study the relative efficiency of a few common acaricides for its control, two trials were carried out at Tocklai. Assessment was made from surviving populations (adults and nymphs) on five mature leaves collected from five bushes selected at random in each plot on two occasions—one and two weeks after treatments. The results of one trial is presented in the table below:—

Table 4 : Purple mite control trial (Tocklai).

Treatments	Average population per leaf (mean of 3 replications) after—		Percent reduction over check after—	
	One week	Two weeks	One week	Two weeks
Aramite 15 W at 1 lb. in 50 gals. water ...	25.4	7.2	93.9	96.6
Aramite 20% E.C. at 1 pint in 93¾ gals water ...	19.5	4.1	95.3	98.1
Akar 338 at 1 pint in 62½ gals. water ...	5.6	2.3	98.7	98.9
Malathion 50% E.C. at 1 pint in 62½ gals. water...	14.3	9.3	96.6	95.6
Lime sulphur at 1 pint in 5 gals water. ...	7.5	2.8	98.2	98.7
Check (untreated) ...	414.9	212.5		
Critical difference at 5% level ...	95.0	61.5		
Rainfall between treatment and observation ...	11.0mm.	14.0mm		

All acaricides tried out in this trial gave significant control of the mite, there being no difference amongst the treatments.

In another trial, similar results were obtained. Though the reduction obtained with Aramite 20% E. C. was superior to check, it was not of the same order as in the previous trial.

Looper Caterpillar (*Biston supressaria* Guen):

A field trial was carried out with DDT, Basudin, endrin and malathion for control of Looper at Kotalgoorie T.E. Count of unaffected Loopers was taken from 9 bushes per plot 48 hrs. and 96 hrs. after the treatment and the results are given below: —

Table 5 : Looper control trial (Kotalgoorie T. E.)

Treatments	Number of caterpillars per bush (mean of 3 replications.)			
	a48 hrs. fter treatment.	Per cent reduction over check.	96 hrs. after treatment.	Per cent decrease (−) or increase (+) over check.
Basudin 20% E. C. at 1 in 500 parts water ...	11.5	37.16	5.7	− 41.48
DDT 20% E. C. at 1 in 500 parts water ...	16.5	9.84	9.1	− 7.14
DDT 50% W. P. 1 lb. plus Teepol 4 oz. in 40 gals water ...	11.5	37.16	6.8	− 30.61
Malathion 50% E. C. at 1 in 500 parts water ...	13.5	26.22	10 0	+ 2.04
Endrex 20 E. C.* at 1 in 1000 parts water . .	0.5	97.26	0.1	− 98.98
Check (untreated) ..	18.3		9.8	
Critical difference at 5% level	5.3		5.64	

*An Emulsifiable concentrate of Endrin.

From the above results it is evident that endrin gave significantly better results than any other treatment within 48 hrs. of treatment. Observations taken 96 hrs. after treatment showed endrin to be significantly superior to all other treatments including check. Though there was a general reduction of

Looper population in all treatments, a slight increase over check was noted in the plots treated with malathion. It should be mentioned here that a considerable number of Loopers died from a bacterial disease, but it was not known exactly how far the bacterial disease was responsible for the reduction of Looper in these treatments.

Flush-worm (*Laspeyresia leucostoma* Meyer.):

Effect of dieldrin treatment of soil on flush-worm incidence.— In order to gain information as to whether dieldrin as a soil treatment against termites increases the flush-worm, a properly laid out trial was carried out in April at Silcoorie T.E. Weekly observations on the number of affected shoots were taken from July onwards by the Advisory Branch, Cachar. The results were analysed separately and jointly for the whole of the season. Though the treatment of dieldrin @ 4 lbs. active material per acre plus sulphate of Ammonia without forking, showed significant increase of flush worm in one week in September, there was no significant difference between different treatments of dieldrin and check at any other time of the year. The overall increase in the incidence of flushworm in the dieldrin treated plots was not significant over check.

According to Senior Advisory Officer, Cachar, the incidence within the actual experimental area could not be related to different treatments of dieldrin and control plots, and this he presumes to be due to smallness of the experimental area. He added that when the attack reached the first peak in the experimental area, there was virtually no flushworm attack on the section outside the experimental area. Weekly observations from 16th September onwards recorded on an average 84.2 shoots affected by flush-worm per acre at each plucking in the experimental area, whereas there was 0.78 affected shoots in the non-experimental area. (See report of Advisory Branch, Cachar).

Assuming that dieldrin had destroyed the natural enemies of flushworm and thereby increased the pest in the experimental area, we find no reason why it should remain confined to the experimental area alone which was about half an acre and

should not spread to the non-experimental area of the section. It should be noted that check plots in the experimental area were affected equally with the treated plots by the flush-worm.

Black thrips (*Haplothrips tenuipennis* **Bagnall.**):

Studies on the life history and habits of this thrips have been completed and the results will be published elsewhere. A few points of interest are given below:

> Contrary to the view held previously that the black thrips is not an injurious but a beneficial insect being predaceous on other thrips (Andrews, 1925*), it has been established through laboratory experiments that this species is primarily a flower thrips, but feeds on leaves when no flower is available.

In a simple experiment, adult thrips were kept in petri dishes (six thrips in each with six replications) with different kinds of food with the following results.

Table 6 : Feeding trial

Food	Average length of life (mean of six replications) (in days)
Tea flowers ...	24.4
Tea shoots ...	10.9
Nymphs and adults of other thrips ...	1.2
Check (no food) ...	1.1

From the above it is evident that there was no difference in the length of life when the thrips were kept with other thrips, from that when kept without food, and all of them in both cases died within 2 days. The length of life was maximum (an average of 24.4 days) in the case of thrips provided with flowers as food, while the average life was only 10.9 days on young shoots. It is, therefore, obvious that this is essentially a flower thrips, but can live for some time on young shoots when flowers are not available.

*Andrews, E. A. (1925) Ind. Tea Ass. Quart. Journ. : 60—105.

The black thrips is quite prevalent during the cold weather on tea, particularly on China bushes, which have more flowers, than at any other time of the year when there is little or no flowering. It has also been found to occur on flowers of various garden crops.

Tea Aphis (*Toxoptera aurantii* Boyer.):

A field trial with various insecticides for control of Aphis was carried out at Cinnamara T.E. As one round of spraying was not considered to be sufficient to deal with the pest, a second round was applied after a week.

Table 7 : Aphid Control trial (Cinnamara T.E.)

Treatments	After a week but before 2nd application.		After 14 days of 1st application and 7 days of the 2nd application.		After 21 days of 1st application and 15 days of 2nd application.	
	Average No of Aphis per bush (mean of 3 replications)	Per cent reduction over check.	Average No. of Aphis per bush (mean of 3 replications)	Percent reduction over check.	Average No. of Aphis per bush (mean of 3 replications)	Percent reduction over check.
Malathion 50% E.C. at 1 in 500 parts water ...	85.1	71.61	13.7	62.36	20.9	31.70
Malathion 50% E.C. at 1 in 750 parts water ...	170.5	43.13	23.4	35.71	24.3	20.59
Malathion 50% E.C. at 1 in 1000 parts water ...	190.2	36.56	27.1	25.55	28.4	7.19
Chlordane 70% E.C. at 1 in 500 parts water ...	165.2	44.90	2.6	92.86	2.5	91.83
Chlordane 70% E.C. at 1 in 1000 parts water ...	242.7	19.05	9.5	73.90	7.7	74.84
Endrex 20 E.C. at 1 in 1000 parts water ...	116.5	61.14	8.2	77.47	3.7	87.91
Endrex 20 E.C. at 1 in 1500 parts water ...	126.1	57.94	17.3	52.47	3.8	87.58
Toxaphene 50% E.C. at 1 in 500 parts water ...	136.9	54.33	12.0	65.93	6.0	80.39
Check (untreated) ...	299.8		36.5		30.6	
Critical difference at 5% level :	123.1		19.80		16.58	

Chlordane, endrin and toxaphene proved equally effective against tea Aphis and there was no difference in efficiency amongst these treatments. Malathion, however, gave initially significant reduction in Aphid population, but there was an increase of the pest subsequently which shows that the reşidual action of malathion does not last long.

Jassid (*Empoasca flavescens* Fabr.):

Incidence.— Monthly observations on the incidence of Jassid on Assam kinds of tea were taken at Tocklai and Borbhetta, on the basis of nymphal population present on 100 young leaves (1—4) collected at random.

Table 8 : Incidence of Jassid in different months of the year 1958.

Months	Tocklai		Borbhetta	
	No. of nymphs per 100 leaves.	Rainfall (in inches)	No. of nymphs per 100 leaves.	Rainfall (in inches)
January* ...	79	0.39	100	0.36
February* ...	130	1.43	118	1.58
March ...	146	0.07	160	0.40
April ...	81	4.03	109	4.61
May ...	29	15 84	48	14 12
June ...	45	8.7	68	7.60
July ...	10	25.52	9	23.75
August ...	11	15.35	3	12.73
September ...	2	5.40	4	4.43
October ...	3	6.64	4	5.90
November ...	15	0.03	30	0.01
December ...	40	0.77	48	1.57

From the above it is evident that the Jassid persists on tea throughout the year. It is more prevalent from January to

*Early pruned tea.

April, when most of the damage is usually caused to tea. From May onwards there is a decline in its population until November, and then the population gradually increases.

Clonal susceptibility to jassid attack.— The susceptibility of different clones to Jassid attack was assessed in the area 50 D at Borbhetta in April, using the index system of 0—4, as used in case of red spider infestation, and the results are presented in table 9.

Table 9 : Clonal susceptibility

Clone no.		Average intensity of attack per bush. (Mean of 2 replications)
16.6 16	...	1.18
19.29.13	...	1.16
1.3.14	...	1.98
16.8.7	...	1.95
19.37.2	...	1.60
1.7.1	...	1.65
19.31.14	...	1.45
16.8.17	...	1.81
19.39.7	...	2 60
19.36.15	...	1 80
3.19.8	...	2.05
19.35.2	...	1.05
16.12.15	...	0.62
24.9	...	2.75
24.11	...	2.05
28.2	...	3.85
16.10.8	...	1.25
3.24	...	1.90
16.4.16	...	0.96
Critical difference at 5% level	...	1.09

All the clones are susceptible to jassid attack in varying degrees. There appears to be some correlation between leaf character and jassid attack and investigations are proceeding in this direction.

Control.— A small field trial with DDT, malathion, toxaphene and endrin was carried out for its control at Borbhetta. The results show that all the pesticides were equally effective in keeping the pest in check for at least one month after which observations were discontinued.

Tea seed bug (*Poecilocoris latus* **Dall.**):

Control.— A field experiment with endrin, dieldrin, Basudin and malathion, with and without pyrocolloid, was carried out against tea seed bug at Borbhetta. Though the treatments of Basudin and malathion with and without pyrocolloid were superior to check, the reduction obtained in the population of tea seed bug is so small that the use of these pesticides for its control is hardly an economic proposition. Pyrocolloid, however, gave knock down of the bugs which dropped on the ground, but recovered sooner or later. If the ground is kept clean, the bugs can be collected easily for destruction after knocking down with pyrocolloid.

Eelworm:

The following nemas have been recorded at Sam Sing T.E. for the first time to attack tea seedlings.

1. *Meloidogyne hapla.*
2. *M. incognita acrita.*

Control.— Three trials were carried out with Nemagon at dosage rates of 1, 2 and 4 gallons per acre at Sam Sing, Lankapara and Jaboka Tea Estates by Messrs. Burmah Shell Company. This branch associated in assessing the efficiency of these treatments. The results did not show significant difference between the treatments of Nemagon and check.

Another trial with HexAmar, Shell D-D and Nemagon was carried out by this branch. None of the treatments gave significant reduction of eelworm infestation over check.

PESTS OF SHADE TREES

Green caterpillar (*Rhesala moestalis* **Walk.**):

Two field trials were carried out to find out the relative efficiency of certain insecticides against this pest. Results are given in tables 10 and 11.

Table 10 : Green caterpillar control—Khoomtai Trial

Treatments	No. of larvae per 10 plants (Mean of 4 replications)	
	After one week of treatment	Percent reduction over check
Endrex 20 E. C. (1 : 1000) (4/5th pint in 100 gals water) ...	1.25	74.4
Dieldrex 18 E. C. (1 : 1000) (4/5th pint in 100 gals water) ...	2.75	87.8
Lindane 20% E. C. (1 : 1000) (4/5th pint in 100 gals water) ...	5.50	75.5
Malathion 50% E. C (1 : 500) $1\frac{3}{5}$ pint in 100 gals water ...	14.75	33.3
DDT 50% WP at 1 lb. in 50 gals water	8.25	63.3
Check (untreated)	22.50	...
Critical difference at 5% level ...	11.45	
Rainfall between treatment and observation ...	3.68"	

The results obtained with endrin, dieldrin and lindane treatments are significantly better than malathion and check, there being no significant difference amongst these treatments. Malathion is not, however, superior to check, while DDT though superior to check, is not significantly better than malathion.

All treatments other than malathion gave significant reduction of caterpillars over check, (Table 11).

Terias hecabe, T. silhetana and Catopsila crocale:

The caterpillars of these three Pierid butterflies are often responsible for considerable damage to shade trees, particularly in nurseries. Studies on the life-history, seasonal incidence, habit and control of these pests are being continued, and the results will be presented in due course.

Table 11 : Green caterpillar control—Dhoolie Trial.

Treatments.	No. of larvae per 10 plants (mean of 3 replications)	
	After one week of treatment	Percent reduction over check
Endrex 20 E.C. (1 : 1000) (4/5 pint in 100 gals water) ...	1.00	94.4
Dieldrex 18 E.C. (1 : 1000) (4/5 pint in 100 gals water) ...	1.33	90.3
Basudin 20% E.C. (1 : 500) ($1\frac{3}{5}$ pint in 100 gals water) ...	4.66	74.0
Aldrex 30 E.C. (1 : 1000) (4/5th pint in 100 gals water) ...	1.33	90.3
Lindane 20% E.C. (1 : 1000) (4/5th pint in 100 gals water) ...	6.66	63.0
Malathion 50% E.C. (1 : 500) ($1\frac{3}{5}$th pint in 100 gals water) ...	14.00	22.2
Check (untreated) ...	18.00	—
Critical difference at 5% level ...	9.32	
Rainfall between treatment & observation ...	2.38"	

SURVEY ON PESTS AND DISEASES

A survey on occurrence of pests and diseases in relation to climatic conditions has been initiated in collaboration with Mycology and Statistical Branches. Questionnaires were issued to 31 tea estates and on the basis of their reply, a second detailed questionnaire was prepared for collection of data by the Survey Assistants on a sub-sample of affected sections.

SCIENTIFIC PUBLICATIONS

Das, G. M. (1957) Preliminary observations on the leaf-rollers and leaf-tiers of tea, with special reference to Flushworm, *Cydia* (*Enarmonia*) *leucostoma* Meyr., in North-East India—Proc. Zool, Soc., Calcutta, **10**, (2) : 107-121.

Ganguli, R. N. (1957) A new species of *Velataspis* (Hemiptera, Coccoidea : Diaspididae) from tea in Assam—Indian J. Ent. **19** (4): 241—**44.**

Das, G. M. & Sengupta, N. Observations on the Pink Mite, *Acaphylla theae* (Watt) Keifer of Tea in North-East-India. J. Zool Soc. Ind. (in Press).

Das, G. M. Observations on the Association of Ants with Tea Coccids Bull. ent. Res. (in Press).

Das, G. M. Bionomics of the Tea Red spider Mite (*Oligonychus coffeae* (Nietner). Bull. ent. Res. (in Press).

Das, G. M. A new Psychid on Tea from Assam. Ann. Mag. Nat. Hist. (in Press).

ADVISORY

Touring.— The Senior Entomologist visited the following gardens during the year: Bhatpara, Rajabhat and Bhatkhowa in Dooars, Attabarie, Balijan North, Thanai, Dhelakhat, Kotalgoorie, Nagadhoolie, Nagajanka, Hunwal, Bokahola and Dhoolie in Upper Assam.

His assistants visited Sam Sing, Lankapara in Dooars, Silcoorie, Borokai, Burnie Braes in Cachar and Methoni, Jaboka, Khoomtai, Kotalgoorie, Murmuria, Dhoolie, Hatichungi, Dessoi, Nagadhoolie, Nagajanka in Upper Assam.

Correspondence.— 387 letters and memoranda were issued during the year.

Examination of specimens.—

Infested tea and ancillary crops	...	178
Soil samples for eelworm estimation	...	855
Pest control products for test	...	21

Publications.— (1) Tea Encyclopaedia Serial No. 103/1, filed under J. 3.

(2) Tea Encyclopaedia Serial No. 99/1, filed under J. 3.

(3) Buprestid Root-Borer of young and Nursery Shade plants—Two & A Bud, No. V (3), pp. 13-14.

GENERAL REMARKS

Red spider was less in evidence at the beginning of the season. It, however, showed up sporadically in April but the attack subsided soon after the break of the monsoon.

Heavy outbreaks of Looper occurred in the districts of Sibsagar, Golaghat and Darrang and also in certain estates in the eastern Dooars. *Helopeltis* caused considerable damage to tea in the sub-district of Nagrakata in the Dooars, and in certain estates in Cachar. This is the first report of its outbreak since the introduction of DDT for its control. Red slug caterpillar appeared sporadically in the North Bank and in the Dooars. Several cases of rim blight following Jassid attack were reported from the North Bank.

Incidence of Flushworm was negligible throughout the year

Acknowledgement.— Co-operation from the management of gardens where trials were carried out is gratefully acknowledged.

PLANT PATHOLOGY BRANCH— MYCOLOGICAL SECTION

K. C. SARMAH—Mycologist.

V. AGNIHOTHRUDU—Asst. Mycologist.

STAFF

The Mycologist was on annual leave for $1\frac{1}{2}$ months from 17th of November to 31st December and the Asst. Mycologist was on annual leave from 16th September to 29th October.

Shri Sarbeswar Buragohain was appointed as Junior Technical Assistant on 1st March, 1958, *vide* Shri K. C. Buragohain retired on 31-12-57.

RESEARCH AND EXPERIMENT

CONTROL OF DISEASES OF THE TEA BUSH

Screening of Fungicides :

Three new formulations of Copper fungicide, supplied by commercial firms were screened in the laboratory, using poisoned-food technique, to test their efficacy against Black rot (*Corticium invisum*). The fungicides will be tested against Black rot in the field by the Pesticide Testing Unit, during the prophylactic spraying period (mid-April to end of May) of 1959.

Winter spraying trials against Black rot :

Two spraying experiments were carried out at Hattichungi Section No. 3C, where Formalin and a liquid emulsifiable formulation of pentachloronitrobenzene (YF 4803) were used at 3 different concentrations against the over-wintering strands and sclerotia of Black rot (*Corticium theae*). The latter was also tried in another estate on individual bushes against *Corticium invisum*.

In both places the tea had a previous history of severe Black rot infection.

Expt. No. 1—In an area of 9 blocks, each consisting of 4 plots of 16 bushes (4 × 4), the following 4 treatments were applied, at the end of January, after cut-across pruning.

Treatments—

(1) 2% Formalin as drench spray.
(2) 4% ,, ,, ,,
(3) 6% ,, ,, ,,
(4) Water ,, ,,

Assessment on the incidence of the disease was made by (1) visual examination of the bushes and putting:

0 for no infection.
1 ,, slight infection.
2 ,, moderate infection.
3 ,, severe infection.

and (2) a leaf sampling technique.

Results have shown that Formalin even at 6% failed to produce any effect on the mycelial strands of *Corticium theae*.

Expt. No. 2—In another area of 6 blocks, each consisting of 5 plots of 16 bushes (4 × 4), the following 5 treatments were applied.

Treatments—

(1) Control—plain water
(2) YF 4803—1% emulsion
(3) ,, ,, —2% ,,
(4) ,, ,, —4% ,,
(5) Coppesan—0.25% on two occasions at an interval of 2 weeks during 1st half of May, 1958.

Assessments on the degree of infection were made as in Expt. No. 1. The results tabulated below indicate that YF 4803 had no effect in killing the overwintering stage of *Corticium theae*.

Table 1

Blocks / Treatments.	I	II	III	IV	V	VI	Total
1. Control	25	18	26	17	21	19	126
2. YF. 4803 1%	19	24	26	19	26	27	141
3. YF. 4803 2%	24	26	31	26	27	18	152
4. YF. 4803 4%	33	24	17	29	21	31	155
5. Coppesan 0.25%	12	18	15	3	10	1	59
Total ...	113	110	115	94	105	96	

Critical difference (P= .05) between treatments totals = 42

Only treatment No. 5, *i.e.* Coppesan 0.25% (applied twice during the phophylactic season) was significantly better than any of the others.

The spraying trials with YF. 4803 on individual bushes formerly affected by *Corticium invisum* also failed to show any effect on the regrowth of the disease.

The cooperation of the Scientific Officer of the Jorehaut Tea Co., Ltd. and of the Managers of the estates concerned in these field trials is gratefully acknowledged.

Healing of wounds:

A small scale pilot trial, on the healing of pruning cuts, on medium pruned tea was undertaken at Tocklai to test the efficacy of 'Arbrex'—a new protective wound paint manufactured by Messrs. Pan Britanica Industries Ltd., U.K. Another trial of the same nature but on a somewhat larger scale will be carried out on medium pruned tea in a neighbouring garden in cooperation with the Scientific Officer of the Jorehaut Tea Co., Ltd.

Assessments on the effect of the paints will be made during the pruning season of 1959 and 1960.

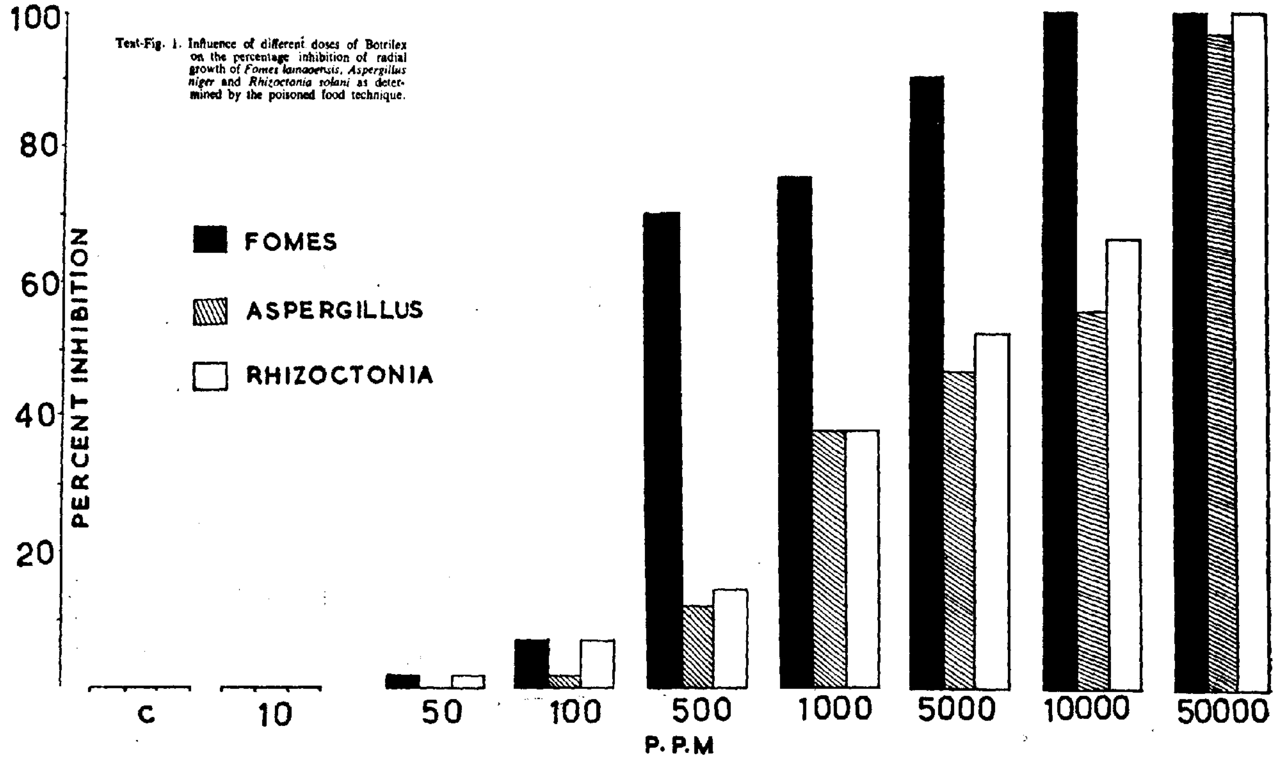
Chemical control of Brown Root Rot (*Fomes lamaoensis*) and Charcoal Stump Rot (*Ustulina zonata*):

In view of the promising control of soil-borne diseases obtained elsewhere by the use of chloronitrobenzene compounds, two preparations of pentachloronitrobenzene, namely, Botrilex and YF. 4803 (miscible PCNB) both containing 20% active ingredient supplied by Messrs. I.C.I. were subjected to a series of rigorous laboratory tests to evalute their efficacy against root diseases.

Fumigant action of Botrilex.— Freshly inoculated cultures of three common soil fungi of the "soil inhabitant" class (*sensu* Garrett) namely, *Rhizoctonia solani* Kuehn, *Aspergillus niger* van Tieghem and *Fusarium solani* (Mart.) Appel et Wollenweber were used. The cultures on potato dextrose agar were suspended with the mouths of the test tubes facing Botrilex placed at the bottom of a tall closed jar. A second set of cultures was similarly exposed to 4% aqueous formalin. To forestall against the possibility of the fumes being heavier than the atmospheric air, a set of cultures was placed under bell-jar with the fungicide kept raised on a tall glass jar.

Daily observations on the growth of different fungi showed neither fungistatic nor fungicidal effect of Botrilex. Formalin was found to be completely inhibitory to the growth of all fungi. Its action was fungicidal. From the results it is clear that Botrilex has no fumigant action on the fungi used.

Influence of Botrilex and YF. 4803 on the growth of ***Fomes lamaoensis*****,** ***Rhizoctonia solani*** **and** ***Aspergillus niger*****,** ***in vitro*****.—** The fungicides were incorporated in potato dextrose agar. The following levels of dosages were investigated: 10, 50, 100, 500, 1,000, 5,000, 10,000, and 50,000 p.p.m. The reaction of the medium was adjusted to pH 4.8—5.2 and agar chunks cut from the edge of one week-old cultures of *Fomes lamaoensis* and *Rhizoctonia solani* were inoculated in the centre of the flask. Spore suspension of *Aspergillus niger* was used to avoid scatter-



Text-Fig. 1. Influence of different doses of Botrilex on the percentage inhibition of radial growth of *Fomes lamaoensis*, *Aspergillus niger* and *Rhizoctonia solani* as determined by the poisoned food technique.

ing of the colonies on the agar medium. A set of 3 replicates was run per treatment.

Diameter of the fungal colonies in different treatments was measured when the controls attained 80 mm of growth (flasks with unamended potato dextrose medium were taken as controls) and the percentage inhibition of growth computed on the basis of controls is represented in histograms (Text Figs. 1 and 2). Concurrently, when the growth, perceptible to the naked eye began in different treatments, colony diameters were measured at intervals along two marked diameters at right angles. Growth rates were calculated and expressed as mean daily increase in colony diameter. The results are presented in Tables 2 and 3.

Table 2 : Showing the mean linear growth per day made by Fomes lamaoensis, Aspergillus niger and Rhizoctonia solani on potato dextrose agar amended with Botrilex.

Dosage of Botrilex in p p.m.	*Fomes lamaœnsis*	*Aspergillus niger*	*Rhizoctonia solani*
	Mean linear growth in mm. per day		
CONTROL	16.0	20.0	20 0
10	16.4	20.0	20.6
50	15.6	20.0	19.5
100	14.8	19.5	18.4
500	5 0	17.5	17 0
1,000	4.0	12.5	12.6
5,000	1.6	10.5	9.5
10,000	0	7.5	6.5
50,000	0	0.8	0
Critical difference at P : 0 01	0 67	0.79	1.1

dextrose agar resumed growth showing that the influence of the fungicide was only fungistatic and not fungicidal within the limits of the laboratory assay.

Table 4 : Showing statistical significance between the mean linear growth per day made by different fungi when grown on potato dextrose agar amended with different concentrations of Botrilex and miscible PCNB (YF. 4803)

FUNGI	FUNGICIDES	STATISTICAL SIGNIFICANCE BETWEEN DIFFERENT DOSES (p.p m)
Fomes lamaoensis	Botrilex	10,C,50, 100,500,1000,5000,10000,50000
	YF. 4803	C,10,50, 100,500,1000,5000,10000,50000
Aspergillus niger	Botrilex	C,10,50,100,500,1000,5000,10000,50000
	YF. 4803	10,C,50,100,500,1000,5000,10000,50000
Rhizoctonia solani	Botrilex	10,C,50,100,500,1000,5000,10000,50000
	YF. 4803	C,10,50,100,500,1000,5000,10000,50000

C : Control.

Similar results were obtained when the experiment was repeated with the classical agar punch method so widely employed in the antibiotic assays. For the sake of brevity the results are not presented in this report.

The results tend to suggest that neither Botrilex nor YF. 4803 is effective against the fungi used in the assay.

Influence of Botrilex on the survival of *Fomes lamaoensis* **and** *Ustulina zonata* **in naturally infected wood.**— With a view to assessing the fungicidal influence of Botrilex on the survival of the two root disease fungi in the naturally infected roots, the following laboratory scale experiments were done.

1. *Influence of Botrilex used as dry mix with the soil :*

Subsoil from an uncultivated plot definitely known to be free from *Fomes lamaoensis* and *Ustulina zonata* was collected

and air dried. Botrilex was thoroughly incorporated with the soil at different rates. The following are the details of the treatments :

1. Control soil not treated with Botrilex.
2. 2 oz. of Botrilex per cubic yard of soil
3. 4 oz. ,, ,, ,, ,, ,,
4. 12 oz. ,, ,, ,, ,, ,,
5. 16 oz. ,, ,, ,, ,, ,,

Four 9″ tall pots were used for each treatment. Freshly collected tea root pieces (2″ long) known to be harbouring the tea root pathogens were used. Each pot contained four pieces of root infected with *F. lamaoensis* and an equal number of pieces infected with *U. zonata*. The individual root pieces were fastened with coloured strings (brown strings for *Fomes* and white strings for *Ustulina*) and buried in the soil with the strings projecting out of the soil. The fastening of coloured strings besides facilitating easy extraction of the root pieces from the soil was also helpful in identifying the root rots at the time of sampling.

Root pieces from different treatments were removed at fortnightly intervals for a period of 6 weeks and the survival of the pathogen assessed. One piece of each of Brown and Charcoal root rot infected roots was sampled from each of the four pots, washed in running tap water followed by 5—6 rinsings in sterile tap water. The roots were split longitudinally under aseptic conditions and incubated in large hard glass test tubes with a wad of moist sterile cotton at the bottom. Observations were recorded after a period of 10 days of incubation in the dark at laboratory temperature. Each individual piece was carefully examined for any growth of mycelium from the black and brown lines (*pseudosclerotia*) inlaying the wood. This growth was taken as the criterion for judging the survival of the fungus. In the case of *Ustulina* fresh spread of mycelium under the bark (fan-wise spread) was also helpful as a test for the survival.

In Tables 5 and 6 are presented the results of fortnightly observations on the survial of the fungi in the naturally infected wood.

Table 5: Number of root pieces yielding Fomes lamaoensis in soils treated with Botrilex.

Treatments	Period of incubation in weeks		
	2 weeks.	4 weeks	6 weeks
	NUMBER OF PIECES YIELDING THE FUNGUS		
1 Control	4	4	3
2 2 oz. Per cubic yard of soil ...	4	4	4
3 4 oz. Per cubic yard of soil ...	3	4	4
4 12 oz. Per cubic yard of soil ...	3	3	4
5 16 oz. Per cubic yard of soil ...	4	4	3

Table 6: Number of root pieces yielding Ustulina zonata in soils treated with Botrilex.

Treatments	Period of incubation in weeks		
	2 weeks	4 weeks	6 weeks
	NUMBER OF PIECES YIELDING THE FUNGUS		
1 Control	4	4	4
2 2 oz. Per cubic yard of soil ...	4	3	4
3 4 oz. Per cubic yard of soil ...	4	4	3
4 12 oz. Per cubic yard of soil ...	3	4	4
5 16 oz. Per cubic yard of soil ...	4	4	3

It is obvious from the results that the treatments had little or no effect at all on the survival of the root rot pathogens in the roots which they have invaded during the parasitic phase.

Concurrently, small pieces of infected root from the core of the experimental pieces were also plated after surface sterilization with 1 : 1000 aqueous mercuric chloride. As most of

the plates were found to be overgrown with *Trichoderma viride* and other diverse soil saprophytes, it is deemed not necessary to present results of observations herein.

2. *Effect of Botrilex used as neat dust on the infected root pieces* :

In a second test, root pieces harbouring *F. lamaoensis* and *U. zonata* in an active state were thoroughly dusted with neat Botrilex and buried in the soil. Six root pieces representing each of the two root rots were removed from the soil at fortnightly intervals and one set of equal number was just freed from the superfluous soil and incubated as before. The results are presented in Table 7.

Table 7 : Number of root pieces yielding Fomes lamaoensis and Ustulina zonata.

Treatments	*Ustulina zonata*		*Fomes lamaoensis*	
	Incubation in weeks		Incubation in weeks	
	2 weeks	4 weeks	2 weeks	4 weeks
1. Treated washed ...	3	2	3	3
2. Treated unwashed ...	3	3	2	3
3. Untreated washed ...	1	1	1	1
4. Untreated unwashed ...	1	1	1	1

Number of pieces used for treatments 1 and 2 : 3 pieces each.
Number of pieces used for treatments 3 and 4 : 1 piece each.

In the treated unwashed series, *F. lamaoensis* and *U. zonata* were seen to grow under the bark but in washed roots growth of *Ustulina* on the bark and *Fomes* from the margins of the pseudosclerotia was apparent. The results suggest that Botrilex is effective only when it comes in direct contact with the fungal mycelium of the pathogen but deeply situated mycelium is far beyond its influence.

As thorough intimate contact of the root pieces harbouring the root rot fungi with Botrilex achieved in the laboratory is

hardly obtainable in the field, it is needless to point out that Botrilex is not at all satisfactory for control of the above two root rots.

3. *Protectant effect of Botrilex* :

In order to ascertain whether Botrilex has any protectant action upon the invasion (active saprophytic colonization) of uninfected roots from sources of buried inoculum in the soil, the following test was done. Three-inch-lengths of pieces of healthy root of tea not known to be suffering from any root rots were washed thoroughly and sterilized in an autoclave at 15 lb. steam pressure for 20 minutes. Each sterilized piece of tea root was fastened intimately with root pieces naturally infected with Brown and Charcoal root rots separately and buried in soil treated with Botrilex at 5 lbs. per cubic yard. Similarly paired root pieces were buried in untreated soils also.

Periodical sampling of sterilized roots did not reveal the presence of either Brown root or Charcoal stump rot pathogens, which observation, however, does not mean that the treatment was effective in preventing the active colonization inasmuch as sterilized roots sampled from the untreated pots were also free from the above pathogens, while the naturally infected roots, both from the treated as well as untreated series, showed unmistakable evidence of *Fomes* and *Ustulina*, the latter in many instances producing its fructifications. From the results reported above it could reasonably be assumed that Botrilex even at the high rates used is ineffectual against the fungus pathogens buried deep in the tissues which they have invaded during the parasitic phase. Further work on the active competitive saprophytic abilities of different tea root rot pathogens in local soils is contemplated.

Effect of YX. 1646/57 on root disease fungi :

Preliminary trials *in vitro* with YX. 1646/57 (Sodium N-methyl dithiocarbamate), supplied by Messrs. I.C.I., using *Fomes lamaoensis*, *Rhizoctonia solani* and *Sclerotium rolfsii* and a member of the *Aspergillus niger* group as test organisms have indicated strong fumigant action of the soil sterilizer. It was found to be fungicidal to *R. solani* and *F. lamaoensis* but

not to the other two fungi on which it was found to exert fungistatic influence only.

Root segments naturally infected with *Ustulina zonata* and *Fomes lamaoensis* were dipped momentarily in three different concentrations of the fumigant, namely 25, 50 and 100% and then buried in the soil. The viability of the fungi was tested after 3 days and 1, 2 and 3 weeks following the treatment using the methods described elsewhere (page 243).

Active mycelium of the pathogens was observed in the roots treated with the lowest concentration, *viz.* 25% while in the other two concentrations, the root pieces were completely overgrown by saprophytic soil fungi, predominantly *Trichoderma viride* (Tode ex Fr.) Fr. and *Penicillium luteum* Zukal. In view of the strong antibiosis exerted by this group of soil inhabitants, further experimental work is necessary to elucidate the selective influence of the fumigant in disturbing the soil biological equilibrium.

TEA FLOWER DISEASE—*Botrytis* sp. (*Sclerotiniaceae*)

Field trials:

Two spraying trials, one at Hulongapar Biclonal seed-bari and the other in the Tocklai campus, were carried out, jointly with the Plant Physiologist, using "Fernide 80" (T.M.T.D.—tetramethyl thiuram disulphide—supplied by Messrs. Plant Protection Fernhurst, Imperial Chemical Industries), and Phygon XL (Diclone—2, 3 Dichloro 1, 4 napthoquinone—supplied by Messrs. Naugatuck Chemical U.S.A.).

Holungapar Plot No. 1.— In this area 72 seed bearers (36 each of clones A & B) were divided into 9 blocks. The following 4 treatments were applied on a pair of clones A & B in each block of 8 trees.

1. Phygon XL at 0.1% (*i.e.* 1 lb. in 100 gallons of water).
2. Fernide 80 at 0.25% (1 lb. in 40 gallons of water).
3. Plain water (equal amount as in Tr. 1 & 2).
4. Unsprayed.

Treatments 1—3 were applied on 5 occasions at weekly intervals commencing from 29th of November; the last application was made on 27.12.57.

Seed collection was made twice weekly from 9.9.58 till 29.11.58. Results are shown in Table 8 and Statistical analysis of the data in Table 9.

Table 8

Treatments	Clones	Total Sinkers	Total Floaters	Clonal total Sinkers	Clonal total Floaters	Ratio Sinkers/ Floaters.
1	2	3		4		5
Tr. 1 Phygon XL 0.1%	Cl. A	8704.0	9133.3	13202.5	13045.7	1.012
	Cl. B	4498.5	3912.4			
Tr. 2 Fernide 80 0.25%	Cl. A	7101.3	6968.7	12453.8	11581.7	1.075
	Cl. B	5352.5	4613.0			
Tr. 3 Water only	Cl. A	7438.0	5072.8	13401.0	9114.4	1.470
	Cl. B	5963.0	4041.6			
Tr. 4 Unsprayed	Cl. A	5999.5	6508.2	9625.5	10708.4	0.899
	Cl. B	3626.0	4200.2			
Total	Cl. A	29242.8	27683.0	48682.8	44450.2	
	Cl. B	19440.0	16767.2			

Table 9: Analysis of variance of the sinker & floater seeds. (yield in hectograms).

Sources	D. F.	M. S. for sinker seeds.	M. S. for floater seeds.
Block ...	8	47.25	14.6
Treatment ...	3	12.60	14.9
Clone ...	1	119.90*	177.4***
Treatment X Clone ...	3	17.00	13.6
Error ...	56	21.60	13.4
Total ...	71		

*, *** significant at 5% and 0.1% levels respectively.

None of the fungicides effected any appreciable improvement over either of the treatments 3 and 4.

Tocklai.— 5 trees of each of clone Nos. 19.29.13 and 19.36.15 were selected for trial. On each tree 6 branches were marked out from which all fertilised ovaries and open flowers were removed and the number of flower buds counted on each branch before application of the following treatments. On each subsequent date of spraying a count was made of all the open flowers on individual branches under treatment.

1. Control (unsprayed).
2. Sprayed with plain water once every fortnight from 2nd December, 1957 (3 applications).
3. Sprayed with 0.25% Fernide once every 4 days from 2nd December, 1957 (7 applications).
4. Sprayed with 0.25% Fernide once every fortnight from 2nd December, 1957 (3 applications).
5. Sprayed with 0.1% Phygon XL once every 4 days from 2nd December, 1957 (7 applications).
6. Sprayed with 0.1% Phygon XL once every fortnight from 2nd December, 1957 (3 applications).

Two assessments were made (1) by counting the number of set fruits in the middle of the season and (2) by counting the number of good and bad seeds after collection of the fruits at maturity.

Analysis of the data, after adjustment of the number of sound seeds per treatment on the total number of flowers, has shown that none of the treatments produced significant effect on seed yield on any of the two clones.

Large Scale Field Trials :

Six large scale field trials with 'Fernide' were carried out in cooperation with the Senior Advisory Officer, Assam and

Mr. W. G. L. Austin of Messrs. Plant Protection, Fernhurst, in the following commercial tea seed gardens.

1. Dhelakhat.
2. Deohall.
3. Thowra.
4. Sealkotee.
5. Tingamira.
6. Khorijan.

A preliminary assessment was made during April—May, 1958, by counting the set fruits on a number of branches which were selected at random from the four quarters of each tree. The fruits only on 1 foot of the branch, measured back from the beginning of the new growth, were counted. The results, however, showed no significant difference between the treatments.

A seventh trial was conducted, with the same fungicide, in a polyclonal seed-bari by the Manager of Tyroon T.E.

The final assessment of the results of all the above trials was made on the daily collection of mature seed during the harvesting period. The experiments and their results are described in detail in the Advisory Branch report.

Cultural studies :

Cultural studies were made on the morphological variation of species of *Botrytis* occurring on different hosts.

The effect of dialized cultural filtrates of *Botrytis* on the germination of tea pollen *in vitro* was investigated.

The rate of growth of germ tubes of *Botrytis* sp. and pollen grains through the style of tea flowers and the influence of "Fernide" (tetramethyl thiuram disulphide) on the germination of *Botrytis* spores and pollen grains were also studied.

All these aspects of the work are described in a separate article, by V. Agnihothrudu *et al.* attached as "Appendix A" to the mycological branch report.

OTHER RESEARCH WORK

Root Diseases and Rhizosphere Microflora :

It has been observed, *ceteris paribus*, microbial density of tea roots infected with Brown root rot and Charcoal stump rot was significantly greater as compared with the uninfected, apparently healthy tea roots.

An undetermined species of *Leptographium* was frequently associated with Brown root rot and several strains of *Cylindrocarpon tenue* Bugnicourt with Charcoal stump rot. Affinities of the latter species, which appears to be a very common member of tea soil mycoflora, were critically examined with special reference to identical fungi isolated elsewhere and the work is hoped to clarify a certain amount of taxonomic confusion arising out of indiscriminate, unnecessary replication of taxa in the Fungi Imperfecti.

Further work on the qualitative nature of soil and rhizosphere microflora with reference to tea root rots is underway.

While testing the fungicidal value of Botrilex (containing 20% active ingredient of pentachloronitrobenzene) against primary root rots, opportunity was availed of studying the effect of the product on soil microflora. The work has been described in "Appendix B" by V. Agnihothrudu and H. K. Phukon.

Survey of Pests and Diseases :

A sample survey of important diseases was started jointly with the Entomological and the Statistical branches. At first a set of questions was issued to 31 Assam tea estates. On the basis of replies received from 27 gardens a second set of a more detailed nature was prepared, the data on which will be collected by the survey assistants.

SCIENTIFIC PUBLICATIONS

1. Agnihothrudu, V—Notes on fungi from North-East India: I. A new genus of Tuberculariaceae. *Mycologia*, **50** (4) : 570-579., 1958.

2. Agnihothrudu, V—Symptomatology and Etiology of the Tea flower Disease.

Annual Report of the Tocklai Experimental Station for 1957, pp. 153-167.

3. Agnihothrudu, V—Notes on Fungi from North-East India. II. An undescribed Myxomycete from Assam. *J. Indian bot. Soc.*, **37** (4): 499-503, 1958.

4. Agnihothrudu, V—A new Species of *Haplosporella* from Hadfield, W. Assam. (*in the press*).

ADVISORY

Touring.— 15 gardens were visited by the Mycologist in connection with disease control and spraying trials.

Lectures and Demonstrations.— The following received training in diseases of tea and its ancillary crops.

(1) The Junior Mycological Assistant in the Pesticide Testing Unit from June to October.

(2) 8 apprentices, in 2 groups, for a period of 2 weeks each.

Examination of specimens and samples.— The following were received for examination.

(1) Diseased specimens of tea, shade plants and green crops	...	688
(2) Water samples for bacteriological test	...	42
(3) Plant protection products for trial	...	2
TOTAL :	...	732

Correspondence.— 316 letters and memoranda were issued in connection with the above samples and disease control.

Publications.— Nil.

GENERAL REMARKS

Incidence of Important Diseases:

Blister blight.— Blister blight was reported from 4 gardens in Upper Assam and one garden in Cachar during the months of April—May. Two gardens in Darjeeling reported its incidence in July and August.

Red rust—(*Cephaleuros parasiticus*).—The Advisory Officers of West Bengal have observed a moderate to severe incidence of Red rust on *Albizzia chinensis*, *A. lebbek* and *Tephrosia candida,* in Darjeeling up to an elevation of 4,500 feet. Its occurrence on tea, however, was not alarming. They have been asked to keep watch on the first appearance as well as persistence of the fructifications during the fruiting season of 1959, so that the best time for chemical control of the disease may be ascertained.

Violet root rot (*Sphaerostilbe repens*).— This was recorded for the first time on a specimen of *Priotropis cytisoides* affected by waterlogging in a lower Assam garden.

Botrytis sp. was recorded on 3 other hosts *viz*. *Plumbago zeylanica* L., *Phaseolus vulgaris* L., and *Oxalis* sp. (see Appendix A).

Drought:

Assam tea estates experienced a very dry period of about 7 weeks from about mid-February to the end of March. Another very hot dry spell prevailed from about the end of May to middle of June, as a result of which sun-scorch on leaves and quite a number of deaths in newly planted tea were reported from various places.

Routine Record of Diseases:

Routine record on the incidence of important diseases of tea, shade trees and green crops in North-East India, built up from examination of diseased specimens received at Tocklai and from the observations made by the Advisory Officers during

their visits to estates, shows the places of occurrence in the following table.

Table 10

Diseases.	Assam Valley.	Cachar.	Dooars	Darjeeling & Terai.	E. Pakistan
1 Charcoal stump rot	17	2	8	...	...
2. Brown root rot ...	13	1	10	...	...
3. Black root rot ...	1	...	...	...	...
4. Purple root rot ...	...	...	2	...	...
5. Red root rot ...	1	...	...	2	...
6. Violet root rot ...	6	1	2	...	...
7. Branch canker (*Poria hypobrunnea*).	34	3	10	3	...
8 Pink disease (*Corticium salmonicolor*). ...	1	...	...	...	...
9. Thorny blight ...	...	...	...	2	...
10. Nectria sp. ...	4	...	...	...	...
11. Red rust (*Cephaleuros parasiticus*). ...	63	5	12	3	...
12. Black rot ...	35	3	9	...	1
13. Blister blight ...	4	1	...	2	...

BACTERIOLOGY

Bacteriological tests of the Tocklai water supply were made at 4 days intervals throughout the year. Results as monthly averages are given below:

Table 11

Months.	Untreated tank water		Treated water	
	Total bacteria per c. c.	Lactose fermenters.	Total bacteria per c. c.	Lactose fermenters.
January ...	38	8	0	0
February ...	4	2	0	0
March ...	0	0	0	0
April ...	0	0	0	0
May ...	0	0	0	0
June ...	134	111	0	0
July ...	107	77	3	0
August ...	83	76	1	0
September ...	88	86	1	0
October ...	64	55	0	0
November ...	66	16	2	0
December ...	96	46	1	0

In addition to the above, 42 samples of water, received from outside estates, were tested for bacterial contamination.

APPENDIX A

INVESTIGATIONS ON TEA FLOWER DISEASE

By V. Agnihothrudu, G. C. S. Barua and K. C. Barua.

Abstract:

Further work on morphological variability of conidia and conidiophores of *Botrytis* occurring on different substrata has revealed variations in dimensions which reasonably fall within the range observed earlier for tea flower isolates. Conidiophores were found to be the most variable as far as their length is concerned. Three more additional auxiliary hosts were recorded bringing the total to 30.

The germ tubes of pollen grains were the first to emerge out of the cut ends of the tea flower styles whether inoculated singly or in association with *Botrytis* on the stigmatic surfaces. Even with a six hour lead, *Botrytis* could not win the race towards the ovary through the stylar canal. The results merit emphasis in that that *Botrytis* by its presence is not able to render the style non-functional as far as the transit of pollen tube is concerned.

Very high concentrations of dialized cultural filtrates of *Botrytis* were indeed strongly inhibitory to pollen germination. The occurrence of such high concentrations not being probable in the field, it is reasonably assumed that *Botrytis* has no role to play in the inhibition of pollen germination by elaborating toxic metabolic products.

Slide germination test with Fernide (TMTD) has shown it to be very effective at low doses, the LD 50 being about 85 p.p.m. and the LD 95 being about 120 p.p.m. for the spores of a local strain of *Botrytis*, used in the assay. The LD 50 for pollen germination was found to be 12,000 p.p.m. which is about 140 times greater than that observed for *Botrytis* for the same lethal dose. The concentration used in the field namely, 1 lb. in 6 gallons of water (16630 p.p.m.) was found to be inhibitory to pollen *in vitro*.

1. **Morphological variability of *Botrytis* found on diverse hosts :**

Further search for *Botrytis* in and around Tocklai has brought to light three more auxiliary hosts, namely *Plumbago zeylanica* L., *Phaseolus vulgaris* L., and *Oxalis* sp. bringing the total number of recorded hosts to 30.

In view of the great cultural variability exhibited by various isolates of *Botrytis* on synthetic and natural media, an attempt was made to compare conidial and conidiophore dimensions of the fungus occurring on different host plants in nature. The measurements which are based on a minimum of 100 readings are presented in Table 1.

Although little variation in colour characters between isolates from different hosts was observed, the dimensions of conidia and conidiophores presented wide range of variation, the conidiophore being the most variable. The overall variation in the dimensions of conidia: 6-20(-22) $\times$ 3-8(-10) μ and conidiophores : 40-300(-450) $\times$ 2-6(-8) μ falls reasonably within the range observed for tea flower isolates (*vide* Annual Report for 1957).

2. **Growth of germ tubes of conidiospores of *Botrytis* and pollen grains through incised styles :**

With a view to investigating the effect of germinating conidiospores of *Botrytis* on the passage of pollen germ tubes through the stylar lumen, the following experiment was done.

Styles were collected from unblossomed tea flowers to avoid extraneous contaminants and brought to laboratory under conditions as far as possible sterile. Only approximately 10 mm lengths of the style were used in the experiment. The inoculation of stigmatic surfaces was done under bacteriologically aseptic conditions. For this, a modified incubation cell was improvised as follows: On the bottom half of 10 cm Petri dishes were placed moistened filter paper pads. Each plate contained a microscope slide which was kept raised on small cut pieces of pith and the Petri dish together with its contents was sterilized in an autoclave at 15 lb. steam pressure for 15 minutes. Subse-

Table 1 : Conidia and Conidiophore dimension of Botrytis occurring on different hosts.

No.	Host.	Conidia (μ)	Conidiophore (μ)
1.	*Poinciana regia* Bojer.	10-14(-18) × 3-6(-8)	120-180(-30) × 3-4(-6)
2.	*Clerodendron infortunatum* L.	12-16(-20) × 5-7(-9)	80-140(-250) × 2-4(-8)
3.	An unidentified Mimoseae.	8-12(-15) × 4-6(-8)	100-200(-350) × 4-6(-8)
4.	*Tephrosia candida* D.C.	14-16(-20) × 5-8(-10)	50 120(-200) × 2-4(6)
5.	*Stylosanthes guyanensis* S. W var *gracilis* (H. B. K.) vog.	10-16(-18) × 3-6(-8)	80-200(-320) × 4-6(-8)
6.	*Crotalaria brownei.*	13-20(-22) × 4-6(-8)	40 100(-180) × 3-5(-6)
7.	*Crotalaria anagyroides* H. B. K.	8-14(-16) × 3-5(-6)	80-200(-350) × 3-6(-8)
8.	*Dianthus* sp.	10-16(-18) × 4-6(-8)	40-120(-200) × 4-6(-8)
9.	*Tropaeolum majus* L.	8-14(-16) × 3-5(6)	120-240(-350) × 3-6(-8)
10.	*Zinnia elegans* Jacq.	12-18(-20) × 6-8(-9)	60-140(-220) × 4-6(-8)
11.	*Petunia* sp.	10 15(-18) × 3-6(-8)	100-200(-300) × 4-6(-8)
12.	*Althea rosea* Cav.	14-20(-22) × 4-6)(-10)	50-180(-240) × 2-4(-6)
13.	*Achania malvaviscus* Swartz.	12-16(-18) × 3-5(-8)	60 200(-250) × 2-4(-6)
14.	*Duranta* sp.	8-12(-16) × 3-5(-8)	120-240(-400) × 3-6(-8)
15.	*Hibiscus rosasinensis* L.	12 14(-16) × 4-6(-7)	70-150(-220) × 2-4(-6)
16.	*Hibiscus schizopetalus.*	14-16(-20) × 5 6(-9)	100 250(-400) × 4-6(-8)
17.	*Eurya* sp.	6-14(-16) × 4-6(-8)	120-180(-250) × 2-4(-6)
18.	*Dahlia* sp.	10-16(-20) × 6-8(-9)	80-150(-200) × 2 4(-5)
19.	*Crossandra* sp.	8-12-(-18) × 6-8(-10)	200-250(-450) × 2-6(-8)
20.	*Nyctanthes arbortristis* L.	12-14(-16) × 4 6(-8)	50-150(-250) × 2-4(-6)
21,	*Euphorbia pulcherrima* Willd.	10 16-(18) × 6-8(-9)	60-180(-240) × 3-5(-6)
22.	*Lathyrus sativus* L.	14-16(-18) × 6-8(-10)	120 240(-380) × 2-4(-6)
23.	*Qui. qualis indica* L.	16-18(-22) × 4-6(-8)	80-220(-280) × 4-6(-8)
24.	*Allamanda cathartica.*	10-18(-20) × 4-6(8)	40-200(-300) × 2-4(-6)
25.	*Dombeya* sp.	10-14(-16) × 4-8(-9)	150-250(-450) × 2-4(8)
26.	*Salvia* sp.	12-18(-20) × 4-6(-8)	40-150(-250) × 4 6(-8)
27.	*Rosa* sp.	14-16(-18) × 5-8 (-10)	80-120(-200) × 2-4(6)
28.	*Plumbago zeylanica* L	12-14(-16) × 4-6(-8)	150-300(-350) × 4-6(-8)
29.	*Phaseolus vulgaris* L.	12-16(-20) × 6-8(-10)	120 250(-300) × 4-6(-8)
30.	*Oxalis* sp	10-12(-14) × 4-6(-8)	80-220(-340) × 2-4(-6)

quently, on each slide were placed four styles under sterile conditions and inoculated on the stigmatic surface. 20 replicates were run per treatment and the following are the details of treatments:—

1. Stigmatic lobes inoculated with spores of *Botrytis*.
2. Stigmatic lobes inoculated with pollen grains only.
3. Stigmatic lobes inoculated with pollen grains as well as spores of *Botrytis*.

One week old cultures of actively growing *Botrytis* on Czapek-Dox agar amended with yeast extract were used in the investigation.

The Petri dishes were incubated at laboratory temperature. After the minimum time for emergence of germ tubes (7 hours in the case of pollen and 30 hours in the case of *Botrytis*), which was determined by a preliminary screening, hourly observations were made on the emergence of germ tubes from the cut ends of the incised styles. The results are presented in Table 2.

Table 2 : Time taken for the emergence of Botrytis *and pollen germ tubes through the cut ends of the incised styles.*

		Time (in hrs.) taken to pass through style (10 mm)	Range (in hrs.) to pass through style (10 mm).
PURE INOCULUM	*Botrytis* spores	38±0·5	34 - 40
	Pollen grains	9±0·3	8 - 12
MIXED INOCULUM	*Botrytis* spores	31±0·3	30 - 32
	Pollen grains	10±0·2	10 - 12

The pollen is able to pass through the style in 8-12 hours while *Botrytis* takes more than 30 hours when inoculated singly or together with pollen.

In another experiment, *Botrytis* was inoculated on the stigmatic surface and subsequent inoculation with pollen grains was done at intervals of 2, 4, and 6 hours to see, if *Botrytis* when given a lead is able to traverse the whole length of the style ahead of the pollen germ tubes. The time taken in hours (corrected to the nearest whole number) for the germ tubes to

emerge from the distal end of the style was reckoned from the time of inoculation. The results are presented in Table 3.

Table 3 : Time taken for the emergence of Botrytis and pollen germ tubes through the cut ends of the style.

Time in hrs. after inoculation with spores.	Inoculum	Mean time taken to pass through the styles (10 mm).	Range (in hrs.) taken to pass through the styles (10 mm).
2 hours	Spores	32±0 4	30 - 34
	Pollen	10±0·3	8 - 12
4 hours	Spores	33±0·2	32 - 34
	Pollen	12±0·2	10 - 12
6 hours	Spores	34±0·4	30 - 36
	Pollen	15±0·4	10 - 16

Even with a six hour lead *Botrytis* is unable to keep pace with the pollen germ tubes.

Whether inoculated singly or in association with *Botrytis* the pollen germ tube far out-distances the fungus in the race through the stylar lumen. One fundamental difference in the nature of growth of pollen and *Botrytis* germ tubes should be noted in this connection. While the pollen tube is able to push through the stylar canal, *Botrytis*, being a typical necrotroph has to pervade the tissues gradually before it emerged at the other end. Besides, there is a difference in the growth rate of germ tubes of pollen and *Botrytis*. The former makes nearly 800-1400 μ of growth in the span of 8 hours whereas the latter hardly attains a length of 100 μ (in distilled water drop).

It is obvious from the results that *Botrytis* is neither able to clog the stylar lumen nor able to keep pace with the pollen germ tube in the passage through the style. Etiologically the results merit emphasis in view of the fact that styles are not colonized before 24 hours after anthesis (vide Appendix, *Annual Report*, 1957), as shown in earlier researches and the chances of *Botrytis* reaching the ovary before the pollen germ tubes appear to be far too remote.

3. **Influence of cultural filtrate of *Botrytis* on the germination of tea pollen grains:**

To test whether the metabolic products of *Botrytis* have any inhibitory or synergistic effect on the germination of tea pollen, the following laboratory trial was undertaken. Monospore cultures of *Botrytis* obtained from tea flowers were grown on Czapek-Dox solution with the following composition:

Sodium nitrate ($NaNO_3$)	2.0	gm.
Potassium phosphate (K_2HPO_4)	1.0	,,
Potassium chloride (KCl)	0.5	,,
Magnesium sulphate ($MgSO_4$, $7H_2O$)	0.5	,,
Ferrous sulphate ($FeSO_4$)	0.01	,,
Sucrose	30.0	,,
Distilled water	1000	ml.

The fungus was grown for a period of 14 days and the cultural fluid filtered through a muslin to remove mycelial remnants. The filtrate was dialized against distilled water in a refrigerator for a period of 7 days. Sterilized Czapek-Dox solution without the fungus was also similarly dialized and included in the assay. The following dilutions were tested for their effect on germination : 1, 2, 4, 8, 16, 32, 64, 128, 256, 512 and plain distilled water served as check.

Drops of the filtrate were dispensed on microscope slides and freshly collected pollen grains suspended in them. The slides were placed on moistened filter paper pads and incubated under bell jars for a period of 12 hours.

Ten fields were examined at random under the low power of a binocular microscope and the number of germinated and ungerminated pollen grains counted per field from which was finally computed the percentage of germinated pollen grains. If the germ tube had not exceeded in length, the diameter of the pollen grain at its widest part, the pollen was considered for all purposes ungerminated.

In the following tables are presented the results of percentage germination of pollen in each concentration of the filtrate and Czapek-Dox (Tables 4-6, Text Figs. 1-2).

Table 4 : *Percentage germination of pollen in cultural filtrates of Botrytis as compared with the distilled water check.*

Concentrations	Filtrate	Czapek-Dox solution
1	0	3·43
2	0·69	5·63
4	28·98	39·97
8	58·24	48·63
16	73·49	113·23
32	107·55	119·23
64	113·46	122·66
128	101·24	113·32
256	104·95	109·89
512	104·67	114·01

Distilled water check : 100%

Table 5 : *Effect of different concentrations of Czapek-Dox solution on germination of pollen.*

Concentrations	Total of 10 replicates	Mean percentage of pollen germination.
1	27	2·7
2	41	4·1
4	288	28·8
8	346	34·6
16	820	82·0
32	871	87·1
64	901	90·1
128	828	82·8
256	796	79·6
512	833	83·3
Distilled water check	725	72·5

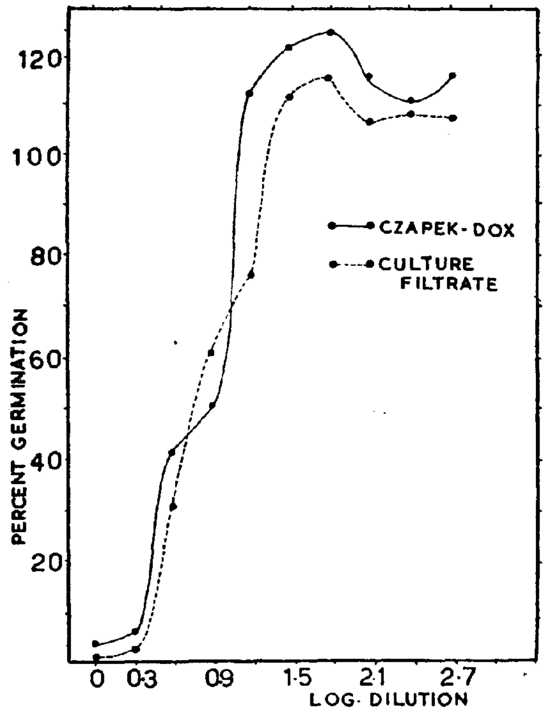
Analysis of variance

Sources	ss	df	mean ss	F
Treatments ...	117402·82	10	11740·282	288·35
Replicates ...	177·04	9	19·671	
Errors ...	3664·36	90	40·715	
Total ...	121244·22	109		

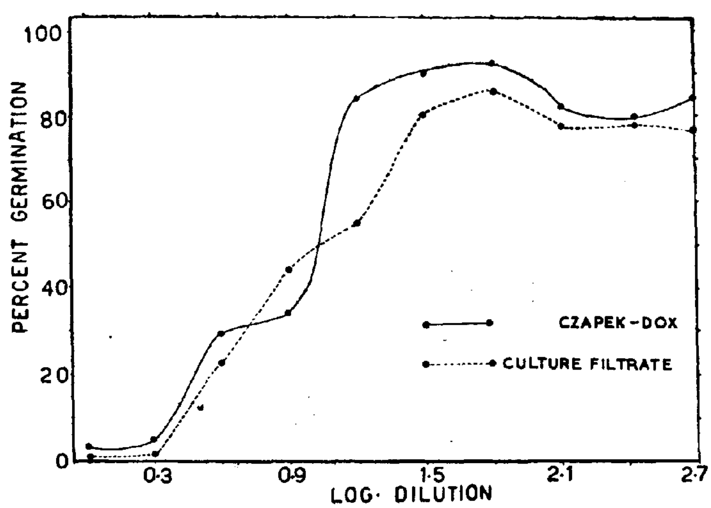
S. E. : $\sqrt{40.715 \times 10}$

C.D. at P : 0 01 : 75.32

Significance : 1, 2, 4, 8, C, 256, 16, 128, 512, 32, 64.



Text-Fig 1. Influence of culture filtrate and Czapek-Dox solution on the percentage germination of pollen grains of tea as compared with the distilled water Check.



Text-Fig. 2. Percentage germination of pollen grains of tea at different dilutions of culture filtrate and Czapek-Dox solution.

Table 6 : Effect of different concentrations of cultural filtrate on the germination of pollen.

Concentrations	Total of 10 replicates	Mean percent of pollen germination.
1	0	0
2	6	0 6
4	209	20·9
8	425	42·5
16	539	53·9
32	785	78·5
64	824	82·4
128	740	74·0
256	765	76·5
512	759	75·9
Distilled water	725	72·5

Analysis of variance.

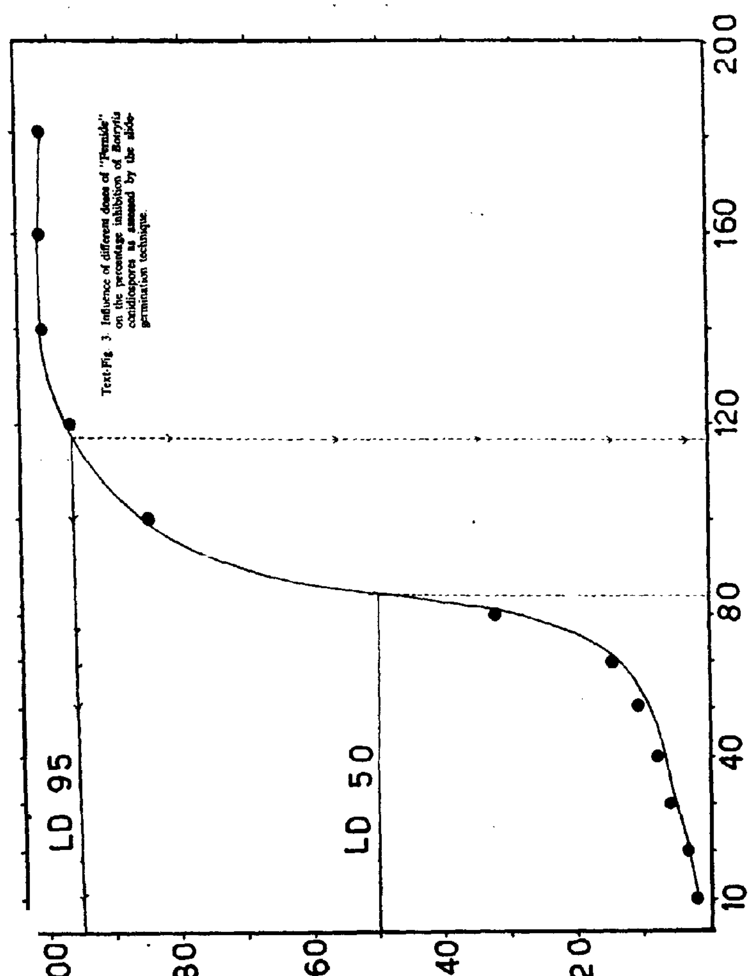
Sources		ss	df	mean ss	F
Treatments	...	101061·96	10	10106·196	271·241
Replicates	...	688·16	9	76·462	2·052
Error	...	3353·34	90	37·259	
Total	...	105103·46	109		

S. E.:
$\sqrt{37.259 \times 10}$
C. D. at P : 0.01 : 72.14

Significance : 1, 2, 4, 8, 16, C, 128, 512, 256, 32, 64

Significant inhibiton of pollen germination is noticeable in the first five concentrations of the cultural filtrate (Table 4 and 6 Text Fig. 1-2) and in the first four concentrations of Czapek-Dox solution (Table 4 and 5, Text Fig 1-2). It is most unlikely that such high concentrations are obtainable in nature. It is, however, interesting to observe slight increase in the percentage germination at lower concentrations over the plain distilled water check which may be due to unmetabolized nutrients present in the medium (Tables 4-6 and Text Figs. 1 and 2).

From the results it is apparent that the metabolic products of *Botrytis* have no significant effect on the germination of pollen



Text-Fig. 3. Influence of different doses of "Pernide" on the percentage inhibition of Botrytis conidiospores as assessed by the slide-germination technique.

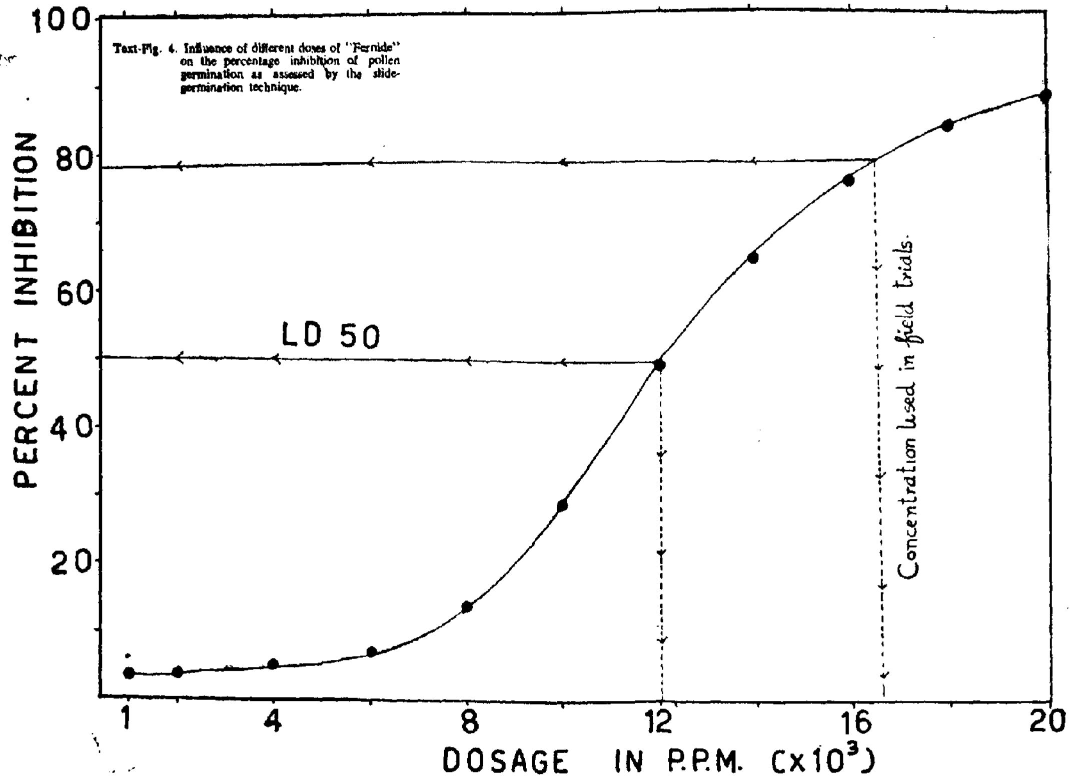
grains *in vitro*. Inasmuch as the results of pure culture studies are not infrequently flattering, it is needless to point out here whether similar conditions are extant on the stigmatic surfaces of the flower in nature where more than one fungus species are always present, with their associative influences which may be inhibitory or synergistic or both.

4. Influence of "Fernide" (tetramethyl thiuram disulphide) on the germination of *Botrytis* spores *in vitro* :

A laboratory trial was set up to assess the toxicity of "Fernide" to the germinating conidiospores of *Botrytis*. Using the well known slide germination test recommended by the American Phytopathological Society, different concentrations of "Fernide" in distilled water ranging from 10 to 200 p.p.m. were sprayed on to slides with an atomizer. After drying, the slides were dispensed with drops of *Botrytis* suspensions, the spore load of which was adjusted approximately to 50,000 per ml. with the help of a Fuchs Rosenthal haemacytometer. One week old cultures of a local strain of *Botrytis* isolated from tea flowers was used in the investigation. Germination counts were taken after 24 hours of incubation at the laboratory temperature. The results are presented in Table 7 and Text Fig. 3.

Table 7 : Effect of "Fernide" on the germination of conidiospores of Botrytis.

Concentration in p.p.m,	Percentage inhibition of germination.
10	2
20	3
30	5
40	7
50	10
60	14
80	31
100	85
120	96
140	100
160	100
180	100
200	100
Check	0



Text-Fig. 4. Influence of different doses of "Fernide" on the percentage inhibition of pollen germination as assessed by the slide-germination technique.

As the proffered doses of "Fernide" were not spaced logarithmically when planning the experiment, the raw data obtained has been plotted on an arithmetic grid, with the concentration on the ordinates and the percentage inhibition of germination on the abscissae.

The results show that "Fernide" is very effective *in vitro* with a LD 50 at about 85 p.p.m. and LD 95 at about 120 p.p.m. for a local strain of *Botrytis* used in the assay.

The concentration of Fernide used in the field trials prior to 1957-58 was 1 lb. in 40 gallons of water which amounts to 2494 p.p.m.

5. **Influence of "Fernide" on the germination of pollen :**

In preliminary screening trials it was found that the concentrations inhibitory to *Botrytis* were not equally inhibitory to the pollen grains. As the LD 50 and LD 95 for *Botrytis* had no significant effect on the percentage inhibition of pollen, higher concentrations of "Fernide" including those which were used in the field were tested. The dosages investigated in the laboratory varied from 1,000 p.p.m. to 20,000 p.p.m. The recommended method of slide germination technique was slightly modified to suit the purpose. As the pollen grains are fairly bigger than the conidia, in order to avoid crowding, the pollen load was initially adjusted to 4,000 to 5,000 per ml and no attempt was made to run sufficient number of higher dosages to establish the LD 95. No wetter was used in the laboratory trial although Teepol was used in field trials.

For convenience in procedure, the dosages were not spaced logarithmically as before. The results are presented in table 8 and Text Fig. 4.

It is apparent, that the LD 50 for pollen is 12,000 p.p.m. which is about 140 times that observed for *Botrytis* for the same Lethal Dose. The concentration used in the field *viz*. 1 lb. in 6 gallons of water (equivalent to 16630 p.p.m.) has definitely deleterious effect on pollen germination *in vitro*. How

Table 8 : Effect of "Fernide" on the germination of pollen grains.

Concentration in p.p.m. (Fernide).	Percentage inhibition of pollen germination.
1,000	3
2,000	3
4,000	4
6 000	6
8,000	14
10,000	30
12,000	49
14,000	65
16,000	75
18,000	83
20,000	86
Check	0

far the results are equally true in the field study could be elucidated only by further experimentation.

APPENDIX B

INFLUENCE OF BOTRILEX ON SOIL MICROFLORA

By V. Agnihothrudu and H. K. Phukon

Abstract :

In analysing the influence of Botrilex (20% Pentachloronitrobenzene) on soil microflora, it has been observed that the fungicide increases fungal numbers up to about a month after its incorporation in the soil as assessed by the dilution plate technique, while the bacterial and actinomycete numbers are observed to show a steep fall. The effect on actinomycetes (*Streptomyces* spp.) appears to be very marked. The increase in fungal numbers could be directly correlated with an increase in spore-derived colonies in the dilution plates. Mycelial forms in the soils were found to be more affected than the sporulating forms. Quantitative and qualitative studies on the mycoflora tend to point out that the action of Botrilex is specific fungistasis rather than one of unspecific fungicidal nature.

Influence of Botrilex on soil microflora :

The essential breakdown processes which make available plant nutrients are brought about by soil microorganisms. The growth of these tiny forms of life is dependent on the maintenance of proper soil environment. Recently introduced compounds designed for the control of soil-borne pests and diseases are demanding more and more attention to determine the possible effects on microbial activity in soil. Since PCNB has shown considerable promise elsewhere for the control of soil-borne diseases a laboratory scale investigation was undertaken to determine the effect of Botrilex on soil microflora.

Composite samples were drawn from soils treated in pots with Botrilex at the rate of 2, 4, 12 and 16 oz. per cubic yard of soil and analysed by the classical dilution plate method. Warcup's (1950) soil plate technique was also used as an adjunct in the qualitative studies on soil microflora. The first estimation was done on the 3rd day after incorporation of Botrilex in the

soil and the subsequent four analyses were done on the 18th, 33rd, 48th and 78th day. Soil from untreated pots served as control. Soil extract agar amended with Rose Bengal and streptomycin sulphate was used for fungi and unamended neat medium for bacteria. The numbers of fungi, bacteria and actinomycetes as affected by different doses of Botrilex are presented in Tables 1, 2 and 3 and Text Figs. 1-3.

Qualitative study of soil bacterial flora.— Soil samples were plated on a non-selective soil extract agar (Löhnis soil extract) without any added energy material. About 50 colonies from each treatment were selected taking due precautions to avoid any preferential selection and stab cultures were maintained in Löhnis soil extract semisolid agar containing 0.02% dipotassium hydrogen phosphate, 0.1% yeast extract and 0.3% agar. By this procedure, all colonies from one Petri plate or all colonies from a certain sector were picked up. The cultures were examined microscopically and on the basis of this examination the isolates were divided into actinomycetes, sporogenous and non-sporogenous bacteria. As regards the percentage of bacteria belonging to different morphological groups, the data, we must own are only approximate. The computations were based on percentage distribution of some 40-50 cultures obtained from representative plates. This number is indeed inadequate, but we have tried to obtain indicative data from a greater number of samples than to obtain more exact results from fewer number of samples only.

Due to considerable cultural work involved in studying 300 bacterial isolates from different treatments, only two estimations could be done, the first being on the 3rd day and the second on the 33rd day after incorporation of Botrilex in the soil.

Bacteriological techniques followed were essentially those recommended by the Society of American Bacteriologists.

Morphological studies included :

1. Negative staining with Dorner's aqueous nigrosin.
2. Motility was studied in hanging-drop suspension of 48-hour old cultures stained with nigrosin.

3. Reaction to Gram stain was studied on the 6th, 15th and 25th days using Gram-Hucker's staining process in order to eliminate the occurrence of Gram variable forms. Where staining reactions were doubtful Beerman-Kopeloff's technique was also employed.

4. Spores were stained in Ziehl's-carbol fuchsin and counter-stained with nigrosin.

Physiological studies :

Semi-solid soil extract agar with 0.1% of potassium nitrate was used for nitrate reduction. Tests for nitrates and nitrites were done on the 10th and 20th days after inoculation. For nitrites α-napthalamine and for nitrates diphenylamine reagents were used. Dextrose utilization was studied on soil extract solution with 1% bromcresol purple indicator. The solution was weakly buffered to neutral.

Results :

Fungal numbers showed a steep rise in the treated series with increasing doses of Botrilex while bacteria and actinomycetes registered a sharp fall up to 33 days after incorporation of the fungicide in soil (Tables 1-3 and Text Figs. 1-3). In the last two estimations an increase in numbers of bacteria and actinomycetes and corresponding fall in fungal numbers was observable.

Using the method described elsewhere (Agnithothrudu, 1955) it was observed that the increase in fungal numbers could be correlated directly with a parallel increase in spore-derived colonies in the dilution plates which may be due to a boosting of sporulation of predominant soil fungi like Aspergilli, Penicillia and Fusaria (Table 5 and Text Fig. 4). The results of qualitative studies obtained by Warcup's (1951) method appear to endorse the above observation. It is clear that the mycelial forms like *Rhizoctonia* spp., basidiomycetes and many other unidentified fungi are considerably reduced in the treated soils.

A sharp reduction in the Gram positive forms and acid reducers was observed in treated soils. Percentage occurrence of nitrate reducers and spore formers showed a steep rise

(Table 4). The occurrence of proteolytic and starch hydrolysing organisms and other morphological groups like short rods, long rods, chains, cocci and coccoid rods was desultory.

A major proportion of the sporogenous strains were related to *Bacillus cereus* group. Among the non-sporogenous isolates, the Gram negative strains obviously belonged to *Flavobacterium, Achromobacter, Pseudomonas* etc. while the Gram positive forms were mostly Corynebacteria.

It may be added here that the reaction of the soil may be another important factor governing the toxicity and stability of the fungicide in the soil. Experiments conducted in this study were made at laboratory temperature. The action of these compounds at higher and lower temperatures needs careful and critical investigation.

Field tests run under fluctuating moisture, temperature and aeration need further investigation for determining the influence of different soil fungicides on the soil microbial balance but conclusions accrued from purely laboratory researches, however, possibly tend to err in the safe direction.

From the view point of common local soil fungi, the action of Botrilex is only selective fungistasis and the results are in conformity with the observations of Strecker (1957).

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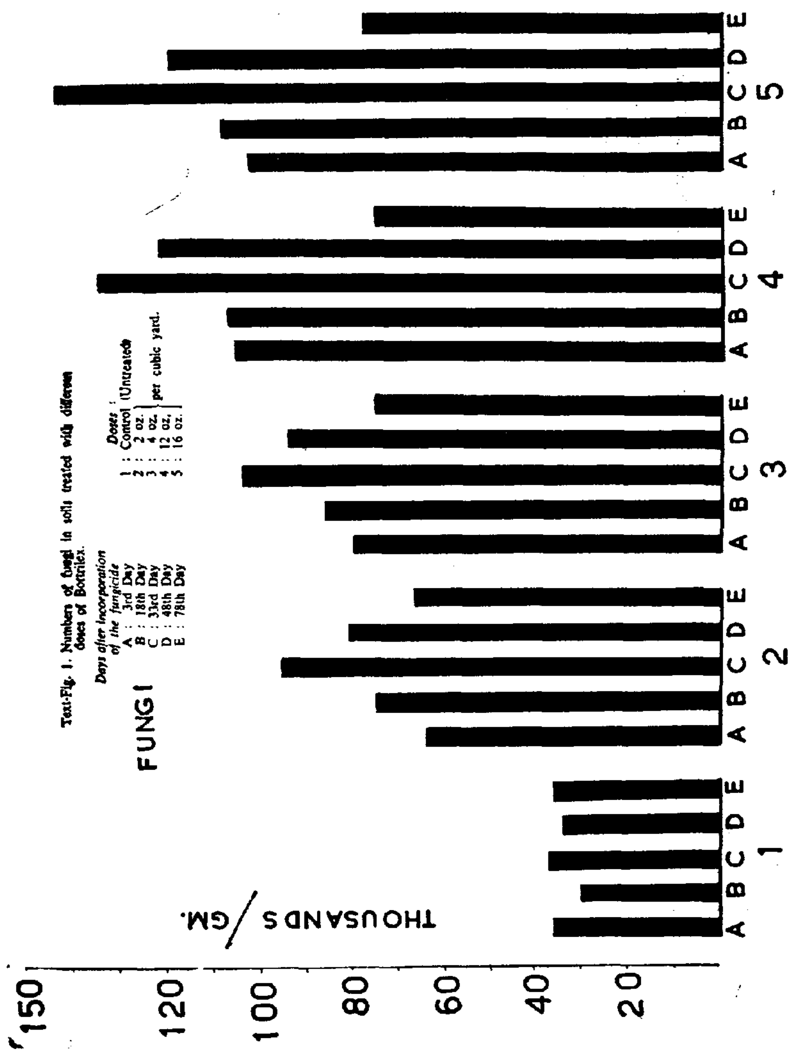
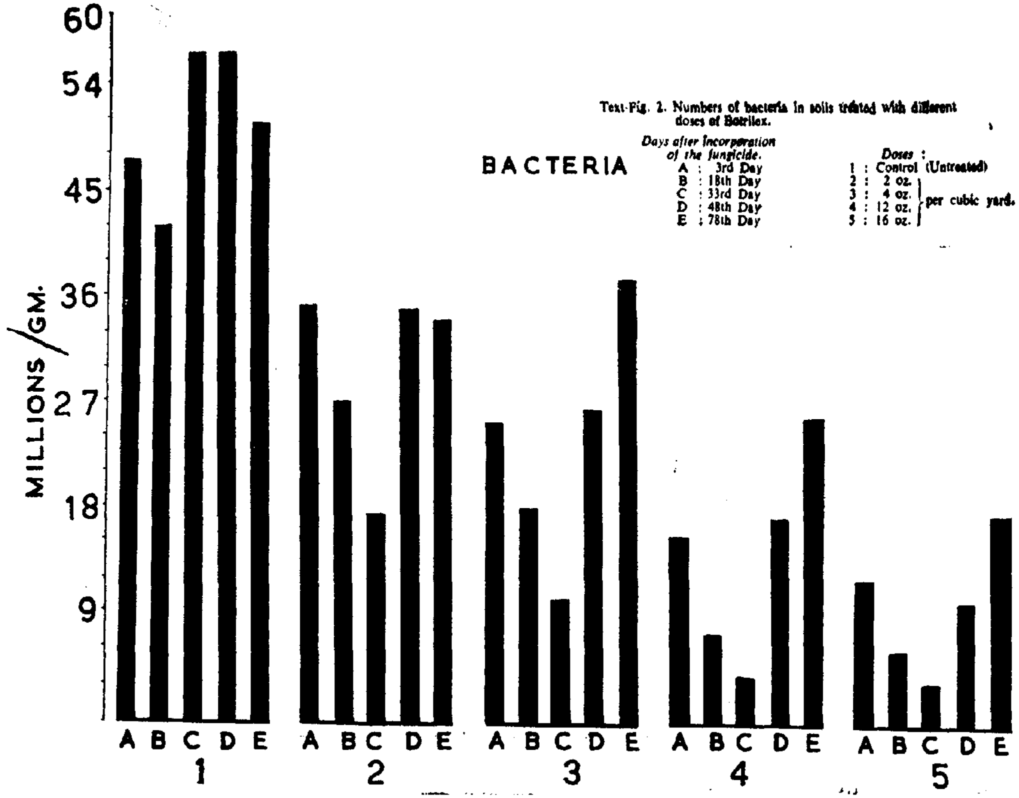


Text-Fig. 1. Numbers of fungi in soils treated with different doses of Botrilex.



Text-Fig. 2. Numbers of bacteria in soils treated with different doses of Botrilex.

Table 1 : Effect of Botrilex on soil fungi (number in thousands per Gm.)

Estimations	Control	Dosage of Botrilex in ozs. per cubic yrd. 2 oz.	4 oz.	12 oz.	16 oz.	Mean
3rd day ...	36.0	64.8	78.5	96.5	103.0	75.76
18th day ...	30.5	77.0	85.5	97.8	108.5	79.86
33rd day ...	36.0	96.5	104.0	134.5	144.0	103.0
48th day ...	33.0	80.8	94.5	122.0	119.3	89.92
78th day ...	34.8	65.5	75.0	75.0	76.5	65.36
Mean ...	34.06	76.92	87.5	105.16	110.26	

Analysis of variance

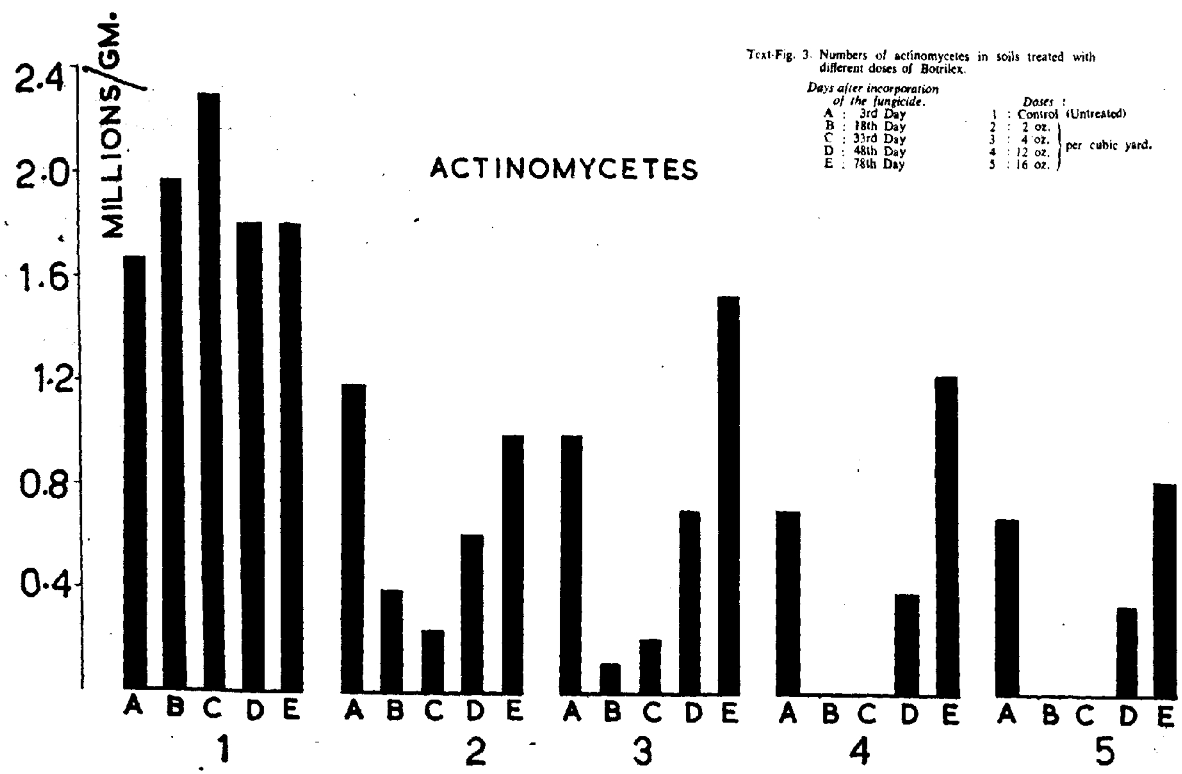
Variation due to	df	ss	Mean square
Estimations ...	4	16290.66	4072.665
Dosages ...	4	72759.26	18189.815
Interaction (Dosages X Estimations) ...		7206.64	450.415
Error ...	75	1188.75	15.85
Total ...	99	97445.31	

Critical difference between estimations : 3.34 } at P : 0.01
Critical difference between dosages : 7.46 }

Results are highly significant.

Table 2 : Effect of Botrilex on soil bacteria (numbers in millions per Gm.)

Estimations	Control	Dosage of Botrilex in ozs. per cubic yrd. 2 oz.	4 oz.	12 oz.	16 oz.	Mean
3rd day ...	47.0	34.0	25.0	16.0	12.0	26.8
18th day ...	42.0	27.0	18.3	7.3	6.0	20.12
33rd day ...	56.0	17.0	10.5	5.0	3.3	18.26
48th day ...	56.0	34.5	26.5	17.0	10.0	28.8
78th day ...	49.8	34.0	37.0	25.5	16.5	32.56
Mean ...	50.06	29.3	23.46	14.16	9.56	



Text-Fig. 3. Numbers of actinomycetes in soils treated with different doses of Botrilex.

Days after incorporation of the fungicide.
A : 3rd Day
B : 18th Day
C : 33rd Day
D : 48th Day
E : 78th Day

Doses :
1 : Control (Untreated)
2 : 2 oz.
3 : 4 oz.
4 : 12 oz.
5 : 16 oz.
(2–5) per cubic yard.

Analysis of variance

Variation due to	df	ss	Mean square
Estimations ...	4	2848.06	712.015
Dosages ...	4	20186.56	5046.64
Interaction (Dosages X Estimations) ...	16	1717.14	107.32
Error ...	75	670.00	8.93
Total ...	99	25421.76	

Critical difference between estimations : 2.5
Critical difference between dosages : 5.6 } at P : 0.01

Results are highly significant.

Table 3 : Effect of Botrilex on soil actinomycetes (numbers in X 10^4 per Gm.)

Estimations	Control	Dosage of Botrilex in ozs. per cubic yard.				
		2 oz.	4 oz.	12 oz.	16 oz.	Mean
3rd day ...	16.5	12.0	10.0	6.8	7.0	10.46
18th day ...	19.5	4.0	1.0	0	0	4.9
33rd day ...	23.0	2.0	2.8	0	0	5.56
48th day ...	18.5	6.3	6.8	4.0	3.0	7.78
78th day ...	17.0	10.0	14.5	12.5	8.8	12.56
Mean ...	18.9	7.02	6.86	4.66	3.82	

Analysis of variance

Variation due to	df	ss	Mean square
Estimation ...	4	841.84	210.46
Dosages ...	4	2994.14	748.535
Interaction (Dosages X Estimations) ...	16	710.76	44.42
Error	75	265.50	3.54
Total ...	99	4812.24	

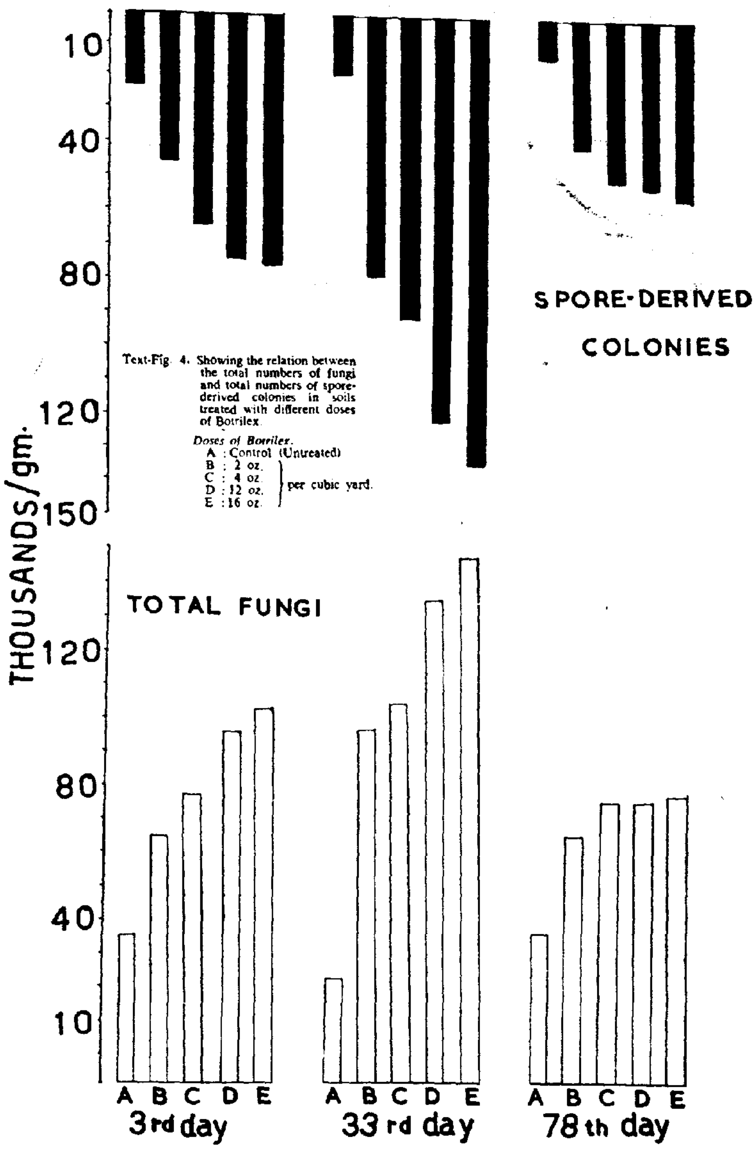
Critical difference between estimations : 1.58
Critical difference between dosages : 2.52 } at P : 0.01

Results are highly significant.

Table 4 : Percentage of morphological and physiological groups of bacteria occurring in soils treated with Botrilex.

	Morphological and Physiological groups.	3rd day					33rd day				
		1	2	3	4	5	1	2	3	4	5
Gram Reaction	Gram positive	58	54	32	34	26	59	34	20	24	20
	Gram negative	34	38	54	60	72	38	60	72	70	75
	Gram variable	8	8	14	6	2	3	6	8	6	5
	Spore formers	62	74	76	74	82	54	86	88	83	89
Dextrose Utilization	Acid formers	54	42	40	26	24	60	35	30	22	24
	Alkali formers	33	48	45	68	70	34	54	65	72	70
	Neutral	13	10	15	6	6	6	11	5	6	6
Nitrate Reduction	Active reduction	63	74	76	85	83	59	82	94	90	94
	Neutral	37	26	24	15	17	41	18	6	10	6

1. Control
2. 2 oz. per cubic yard of soil.
3. 4 oz. per cubic yard of soil.
4. 12 oz. per cubic yard of soil.
5. 16 oz. per cubic yard of soil.



Text-Fig. 4. Showing the relation between the total numbers of fungi and total numbers of spore-derived colonies in soils treated with different doses of Botrilex.

Doses of Botrilex.

A : Control (Untreated)
B : 2 oz.
C : 4 oz.
D : 12 oz.
E : 16 oz.
per cubic yard.

Table 5 : Percentage fungal colonies arising from spore units in soils treated with Botrilex.

Estimations	Control	Botrilex in ozs. per cubic yard of soil			
		2 oz.	4 oz.	12 oz.	16 oz.
3rd day	62	72	78	76	73
33rd day	58	84	88	92	96
78th day	56	70	76	78	78

PLANT PATHOLOGY BRANCH—PESTICIDE TESTING UNIT

T. D. MUKERJEA—Pesticide Testing Officer.

STAFF

Dr. T. D. Mukerjea took up his appointment as Pesticide Testing Officer on 14th February, 1958. Mr. M. C. Katani was transferred from the Entomological Section to the Testing Unit as Senior Laboratory and Field Assistant with effect from 1st April, 1958. Mr. M. C. Barthakur joined the Unit as Junior Mycological Assistant on 2nd June, 1958. Mr. A. Acharyya joined the Unit as Typist-Clerk on 26th November, 1958.

RESEARCH AND EXPERIMENT

SCREENING OF PESTICIDES

Insecticides and acaricides:

Tedion V-18.— Laboratory experiments on Red spider mite were carried out to study the ovicidal properties of Tedion V—18. This product is a sulphur containing compound and chemically it is 2, 4, 5, 4 Tetrachloro-Diphenyl Sulphone.

Effect of Tedion as an ovicide.— The ovicidal tests were carried out in the laboratory. Technique was standardised. Tea shoots bearing the eggs were subjected to a direct spray by an Air-brush spraying equipment with different concentrations of Tedion V-18. The results of the effect of different concentrations of Tedion V-18 on the eggs of Red spider are given in Table 1.

Table 1

Treatments	Percent mortality of Red spider eggs (mean of 5 replications)		
	First Trial	Second Trial	Third Trial
Tedion V-18 W.P. at 1 gm. in 500 cc water	73.73	81.96	81.90
-do- at 1 gm. in 750 cc water	55.60	65.10	71.50
-do- at 1 gm. in 1000 cc water	46.76	35.20	48.60
-do- at 1 gm. in 1500 cc water	30.68	32.40	39.40
Critical difference at 5% level	9·34	10.84	12.32

Tedion V-18 was ovicidal and had an effect on the embryonic development of some of the eggs. Some affected eggs developed as usual but the larvae did not hatch after the normal incubation period. From Table 1 it would appear that to achieve kill between 70 to 80%, a higher concentration *i.e.* 1 in 500 parts is required.

Effects of Tedion V-18 on adults and Nymphs.– The effect on the adults and nymphs was also studied. The results are given in Table 2. The figures are those of percentage of total kill *i.e.* of adult and nymph together.

Table 2

Treatments	Percent mortality of red spider adults (mean of 5 replications)	
	First trial	Second trial
Tedion V-18 W.P. at 1 gm. in 500 cc of water	39.5	54.0
-do- at 1 gm. in 750 cc of water	20.7	50.0
-do- at 1 gm. in 1000 cc of water	14.2	28.7
-do- at 1 gm. In 1500 cc of water	12.3	28.0
Critical difference at 5 % level	13.48	

Results set out in Table 2, show that Tedion V—18 has got a limited contact poison effect on the adults. At the highest concentration used the percentage of kill was between 39.5 and 54.

Effect of Tedion V-18 on the developing eggs in the ovary.—To investigate the possible influence of Tedion on the developing eggs in the ovary, females were placed on tea shoots and were subjected to a direct spray with a measured amount of the liquid. One hour after spraying the adult females were removed to fresh untreated leaf-shoots for oviposition. Likewise, the females were continually transferred each day to fresh shoots till they ceased to lay eggs. A control series never exposed to the compound was also transferred daily to untreated leaves.

The results are set out in Table No. 3.

Table 3 : Percentage of dead eggs on untreated leaves on given days, after transfer from sprayed leaves

Treatments	1 day	2 days	3 days	4 days	5 days	6 days	7 days	8 days	9 days	10 days	11 days	12 days
Tedion E.C. 1 in 500 parts	76.9	99.5	94.3	99.7	95.1	88.8	84.7	60.6	23.8	27.7	11.5	23.8
Tedion W.P. 1 in 500 parts	37.5	70.4	69.3	65.5	50.7	31.6	22.0	13.5	5.7	13.2	43.1	30.0
Tedion E.C. 1 in 1000 parts	44.2	67.7	78.6	74.1	74.0	53.0	37.9	29.6	11.8	17.6	31.7	11.1
Tedion W.P. 1 in 1000 parts	23.2	40.2	48.9	40.0	23.9	22.2	20.7	19.2	13.1	11.4	26.1	0.0
Check	1.2	3.7	5.8	4.7	6.8	3.6	1.5	0.9	18.2	5.1	32.1	30.0

It is evident from the results set out in the above table that the viability of eggs laid subsequent to spraying, progressively decreased. Most of the eggs laid on the untreated leaf-shoots during the first 5 days by females previously exposed to Tedion were sterile. After this period proportion of viable eggs increased and after 8 days the effect of Tedion was practically lost.

Comparative study of efficacy of Tedion, Akar and Lime sulphur against Red spider population.— A series of experiments were conducted in the laboratory to find out the comparative efficacy of Tedion, Akar and Lime sulphur against active forms of Red spider. An initial population of Red spider was started on potted plants. After this was established the potted plants were sprayed with the air-brush equipment, with a measured amount of liquid insecticide. The results are set out in Table 4.

It will be seen from the results that Tedion V—18 acts slowly as evidenced by its low kill after 24 hrs. as compared with other two acaricides. But progressively the rate of

Table 4

Treatments	Trial No. I : Date of application—11-8-58 Dates of observation—12-8-58, 18-8-58, 25-8-58 & 8-9-58. Number of living population after (mean of 5 replications)				Trial No. II : Date of application – 1-9-58. Dates of observation—2-9-58, 8-9-58, 16-9-58 & 29-9-58. No. of living population (mean of 5 replications) after			
	24 hrs.	7 days	14 days	28 days	24 hrs.	7 days	15 days	28 days
1. Tedion V-18 W.P. at 1 lb. 50 gals. water	151.8	11.8	4.2	0.8	71.6	18.2	3.2	2.8
2. Akar 338 at 1 in 500 parts water	5.8	8.2	8.6	7.8	6.0	9.6	7.8	8.4
3. Lime sulphur at 1 in 40 parts water	2.2	4.0	5.0	1.6	2.6	5.6	6.0	6.6
4. Check (water sprayed).	288.0	258.2	69.0	48.6	142.8	192.0	170.8	65.2
Critical difference at 5% level	23.83	3.48	3.06	3.12	8.5	7.1	3.0	5.8

kill increased and at the end of 28 days it produced a significantly higher mortality than Akar 338.

Kelthane. —Laboratory experiments were carried out with this new acaricide, containing 15% active ingredients. Chemically it is 2, 2-bis-(p-chlorophenyl)-2-hydroxy-1, 1, 1-trichloroethane. A series of preliminary trials were conducted with different concentrations of the product to ascertain a dose-mortality ratio. At a concentration of 1 part in 1,000 it gave 95% control as against check.

Comparative effectiveness of Kelthane with Akar and Tedion V-18.— In order to study the comparative effectiveness of Kelthane, laboratory trials on potted plants were carried out with Akar 338 and Tedion V-18. Two concentrations were taken for Kelthane. The potted plants were sprayed with the respective acaricides with an Air-brush spraying equipment using a known amount of liquid. Immediately after spraying,

an initial count of red spider was taken. Observations after spraying on the mortality of red spider (active forms) were recorded after 24 hrs., 1 week, 2 weeks and 4 weeks. The results are presented in Table 5.

Table 5: Comparative study of Kelthane, Tedion V 18 and Akar 338 on red spider population.

Date of treatment : 8.10.58.
Dates of observations : 9.10.58, 15.10.58, 22.10.58 & 7.11.58.

Treatments	Number of living red spider population after (mean of 5 replications)			
	24 hrs.	1 week	2 weeks	1 month
Kelthane 15% E. C. at 1 in 800 parts water	8.6	0.0	0.0	0.0
-do- at 1 in 1600 parts water	25.4	2.8	1.6	0.2
Tedion V-18 W. P. at 1 lb. in 50 gals water	47.6	21.2	6.0	2.0
Akar 338 at 1 in 500 parts water ...	22.4	4.6	4.0	4.4
Check (water sprayed)	123.6	95.6	75.6	66.0
Critical difference at 5% level ...	7.13	5.00	3.44	4.23

The results set out in above table show that Kelthane in dilution 1 in 800 parts is significantly better than other acaricides after 24 hrs. Keithane at 1 in 1,600 parts is as good as Akar 338 but inferior to Kelthane 1 in 800 parts and better than Tedion V-18 and check after 24 hrs. After one week of application there was no significant difference amongst the treatments— Kelthane 1 in 800 parts, 1 in 1,600 parts and Akar 338. These in turn maintain same trend as in 24 hrs. After two weeks of application there was no significant difference between Kelthane 1 in 800 parts and 1 in 1,600 parts; Kelthane 1 in 800 parts was significantly better than Akar 338 and Tedion V-18. After four weeks of application there was no significant difference between Kelthane 1 in 800 parts, 1 in 1,600 parts and Tedion V-18. Kelthane 1 in 800 parts was significantly better than Akar 338.

Fungicides :

Three copper formulations were tested for their efficacy *in vitro* against *Corticium invisum* Petch, one of the agents causing

Black rot of tea. As there is considerable risk of getting different physiological strains of the fungus if spore samples are collected and bulked from the field, the mycelial form was used in the assay employing poisoned food technique.

Different concentrations of the formulations were prepared in potato dextrose agar and equal aliquots of the medium dispersed in 250 ml. Erlenmeyer flasks. As the difference in pH between the different concentrations was negligible in comparison with the check, no attempt was made to adjust the reaction prior to inoculation.

Agar chunks of uniform size removed from the edge of an actively growing one-week-old culture of the fungus on potato dextrose agar were used, and, as it was found difficult to maintain the uniformity of the inoculum size, the experiment was repeated using mycelial suspension. It may be noted here that the agar chunk method of inoculation gave rise to colonies that had irregular frayed margins, which was obviated by the mycelial drop method. The diameter of the colonies was measured at right angles with one another and the results presented in Table 6 are based on the mean percentage inhibition of growth in different treatments (thrice replicated) when the controls attained 80 mm. of radial growth.

Table 6

Dosage of Cu in parts per million	Percentage of Inhibition		Dosage of 'Cu' in parts per million	Percentage of Inhibition 'Duphar colloidal' copper
	Fytolan	Cupricol		
37.5	5	5	25	15
75	18	19	50	27
150	40	24	100	27
300	63	31	200	38
600	67	51	400	63
1200	71	100	800	92
2400	71	100	1600	100
4800	84	100	3200	100

The lethal doses in terms of concentrated form, for different formulations computed from the dosage response curve are:—

Table 7

Formulations	LD_{50}	LD_{95}
Fytolan 50% ...	0.04%	...
Cupricol 50% ...	0.12%	0·24%
Duphar Colloidal Copper 15% ...	0.19%	0.67%

Further investigations are necessary before any definite conclusions are drawn from these laboratory trials.

Nematocides:

Four field trials with Nemagon, Nematox, Sistan and Basudin have been laid out to find out whether these materials are toxic to the nemas which attack tea in nurseries, and to test their phytotoxicity to tea plants. The experiments have been laid out in randomised plots with six replications of each treatment. These are long term experiments and likely to be finished by November, 1959.

STANDARDISATION OF TEST INSECTS AND MITES

Abundant evidence is available to show that, to a varying extent all isnecticides are specific in their action on insect or mite species. In the study of inseticidal action and particularly in the search for new insecticides it is important that the specificity of the insecticide should be examined. For such work, it is necessary to rear a range of insect or mite species in the laboratory using techniques which are capable of maintaining healthy individuals of uniform resistance.

Only two species, one an insect and the other a mite were selected in the beginning for rearing in the laboratory. These are Looper caterpillar, *Biston suppressaria* Guen., and Red

spider, *Oligonychus coffeae*. The following factors affecting the rearing are taken up for this study:—(*a*) Food plant, (*b*) Temperature, (*c*) Humidity and (*d*) Illumination.

Food-Plant :

The food plant for these is tea, and tea seedlings can be raised and be available in quantity throughout the year. The potted tea seedlings, raised in the laboratory in potted plants show much variation in the texture and physiological condition according to the time of the year, a factor which may cause variation in vigour of insects feeding on them. Although no difference in resistance to insecticides has been recorded, it is clear that an attempt should be made to standardise the condition of the food plant or at least make it more uniform. The main difficulty encountered is to induce normal plant growth during winter. The factors responsible may be (1) Temperature and (2) Illumination. This needs investigation.

Temperature :

Temperature is important because it determines the rate at which insects can be produced. The higher the temperature the shorter is the life-cycle, with the result that batches of insects or mites may be reared with less labour in a shorter period of time. Thus it is important to determine the highest temperature which satisfies the requirements of (1) relatively low mortality during development and (2) production of normal full-sized adults.

Effect of temperature on development of eggs, larvae and nymphs of mites (*Oligonychus coffeae*).— It has been pointed out in the literature that the critical temperature of a number of plant-feeding insects and mites is low *i.e.* 32—34°c. Experiments have been designed and are in progress to determine the effect of such temperatures on Red spider developments and the active forms were reared from hatching at constant temperature of 30°c (just below the critical temperature) and 34°c (just above the critical temperature). Preliminary experiments carried out in the laboratory show that at 30°c the mortality during develop-

ment to the adult stage was not too high, whereas at high humidity—90 to 100% R.H., a temperature of 34°c is lethal. This needs confirmation and investigations are under way.

Humidity :

Humidity has a very marked influence on the development of mite population. Low humidities are most likely to affect the mites when the temperature approaches the critical temperature and the normally efficient waterproofing mechanism of the mites begins to fail. It has been recorded that between 60-70% R. H. the mites in all stages develop successfully at about 25°c. The influence of humidity on the eggs and pupae requires investigation because neither of these two stages in the life-cycle is capable of replacing water lost by transpiration.

Illumination :

In experiments carried out to study the influence of illumination on mites on potted plants, it was noticed that in total darkness there is no migration. But on the potted plants infested with mites, kept in darkness in one side and the other side towards the source of light, mites tend to migrate towards light and the uninfested potted plants kept nearer the source of light get infested. This indicates that mites are phototropic. This is under investigation.

TECHNIQUE STANDARDISATION

In order to increase the efficiency and precision of the techniques used for evaluation of pesticides, comparative tests were carried out to check whether different techniques have any adverse effect either on the host plants or on the test subjects.

Maintenance of test subjects after treatment :

The susceptibility of the insect or the mites and the potency of the insecticide are largely dependent upon factors external to the test subject, such as temperature, humidity, food and the period of maintenance of the test subjects after spraying until assessment. The types of vessel and the subs-

tratum in which they are confined after spraying and particularly the conditions in which they are confined, are important.

(a) **Leaf-method.**— This particular method is designated--"Leaf-method" because, a single tea leaf shoot is taken as a "substratum" on which mites are confined and then sprayed After spraying, sufficient time is allowed for drying. After the leaves are dry the mites are counted on each sprayed leaf-shoot and are then confined in a glass tube open at both ends and stoppered at the lower end with a cork. A hole is bored in the middle of the cork through which the twig is passed. The other end of the tube is covered with muslin held tight with a rubber band. The leaf-shoots with mites confined in tubes are then immersed in test tubes filled with water to keep the shoots fresh. These in turn are kept on a specially constructed stand for observation. Experiments carried out in the laboratory showed that the mites in tubes can be confined up to a period of ten days without any visible deterioration of the tea shoots. There was apparently no change in micro-climate inside the tube, especially the humidity. There was no accummulation of moisture on the sides of tubes, which usually happens in a closed container. Migration of the mites was nil and the mortality in the control was negligible.

(b) **Potted Plant method.**— In this method instead of taking one single leaf as in the "leaf-method", a potted tea plant is taken and mites are introduced on it. After spraying the potted plant sufficient time is allowed for drying. After the leaves are dry the individual plant is enclosed in a muslin bag. Experiments carried out showed that mites can be kept confined on the potted plants up to a period of one month without much adverse effect on the host plants or the mites themselves. Migration of the mites is a problem. The problem of checking the migration is under investigation.

TAINTS ON MADE TEA DUE TO APPLICATION OF PESTICIDES

The following agro-chemicals were applied on 5.11.58 after plucking. Samples of made tea from the treated plots after

one and two weeks of treatment were sent to Tea Taster. The reports of the Tea Taster on made tea are given below.

Table 8

Treatments	Set	Replications	Date of plucking 12-11-58 Comments	Total rain fall after treatments	Date of plucking 19-11-58 Comments	Total rainfall
Endrex 20 E.C. at 1 in 1000 parts water	A	1	Not tainted	Nil	Not tainted	Nil
		2	-do-		-do-	
	B	1	-do-	,,	-do-	
		2	-do-		-do-	
Aldrex 30 E.C. at 1 in 1000 parts water	A	1	Not tainted	Nil	Not tainted	
		2	-do-		-do-	
	B	1	-do-	,,	Unpleasant cup character.	
		2	Objectionable green taste in cup.		Not tained.	
Dieldrex 18 E.C. at 1 in 1000 parts water	A	1	...	Nil	Not tainted	
		2	...		-do-	
	B	1	...	,,	-do-	
		2	...		-do-	
Dieldrin 50% W.P. at 1 lb. in 50 gals. water	A	1	..	Nil	...	
		2	...		...	
	B	1	...	,,	...	
		2	...		...	
Malathion 50% E.C. at 1 in 500 parts water ...	A	1 2	Objectionable green taste in cup.	Nil	Unpleasant green character in cup.	
	B	1	Not tainted	,,	Not tainted	
		2	Objectionable green taste in cup.			
Kelthane 15% E.C. at 1 in 800 parts water	A	1	Not tainted	Nil	Not tainted	
		2	-do-		-do-	
	B	1	-do-	,,	-do-	
		2	-do-		-do-	
Tedion V-18 W. P. at 1 lb. in 50 gallons water ...	A	1	Not tainted	Nil	Not tainted	
		2	-do-		-do-	
	B	1	-do-	,,	-do-	
		2	-do-		-do-	
Check ...	A	1	Not tainted	Nil	Not tainted	
		2	-do-		-do-	
	B	1	-do-	,,	-do-	
		2	-do-		-do-	

Evaluation of Residue on made tea

In order to evaluate the residues of Malathion carried over to made tea, a trial was conducted at Borbhetta Experimental

Garden on 6.11.58. The details of the experiments are as follows:—

Treatments : A. Malathion 57% E.C. at 1 in 400 parts water.

B. Malathion 57% E.C. at 1 in 800 parts water.

C. Check.

Date of treatment—6.11.58.
Date of plucking for manufacture—13.11.58.
No. of replications—3 (in each treatment).

The samples of made tea (1 lb. from each replicate, 9 lbs. total) thus obtained have been sent to the manufacturer for evaluation of residues and the results are awaited.

Certification of Pesticides and Herbicides

Renewal of certificates :

Certificates of approval for products previously issued by Tocklai were renewed. The following thirteen such products had renewal of certificates of approval:—

(1) Star Brand Lime Sulphur solution 30° and 33° Beaume, (2) Tillex, (3) Copper Sandoz 50% cuprous oxide, (4) Shell Copper fungicide, (5) Aldrex 50% dust, (6) Aldrex 40 W. P., (7) Dieldrex 50 W.P., (8) Dieldrex 18 E.C., (9) Guesarol 550 (50% W.P.), (10) Hexidole 950 (50% BHC W.P.), (11) Hexidole 805 (5% BHC dust), (12) Blitox-50 (50% copper oxychloride W.P.) and (13) Phenoxyelene 30 (M.C.P.A.).

Products under test for certification :

The fallowing products have been accepted by the Unit for test No. 1 and 2.

1. Nemagon—a soil fumigant—against root-knot nematodes of tea seedlings.

2. Tedion V-18—an acaricide (Prophylactic and Palliative treatments) against red spider of tea (two sets of tests 1 and 2).

3. Duphar Colloidal copper—a fungicide against Black rot.

4. Kelthane—an acaricide—against red spider.

5. Endrex—an insecticide—against Looper caterpillar.

The following products have been accepted for Check tests:

1. Shell 2, 4-D—a herbicide against Dicotyledonous weeds.

2. Aldrex 30 E.C.—an insecticide against soil pests, termites and crickets etc.

ADVISORY

Touring.— The Pesticide Testing Officer visited Murmuria, Kotalgoorie, Nagadhoolie, Nagajunka, Dhoolie, Hunwal and Bokahola Tea Estates, a number of times, in connection with spraying experiments. He also visited Thanai and Khoomtai Tea Estates.

Correspondence.— 119 letters were issued.

BIOCHEMICAL BRANCH

I. S. BHATIA—Senior Biochemist.

N. B. CHANDA—Biochemist.

STAFF

Mr. D. J. Wood resigned his post and left the station on the 20th. April. Dr. I. S. Bhatia joined Tocklai as Senior Biochemist on August 16th

RESEARCH AND EXPERIMENT

CHEMICAL INVESTIGATIONS

Chemical Differentiation of Tea Varieties:

Roberts *et. al* (New Phytologist, 57, 211-225, 1958) studied the phenolic substances of different forms of tea and of species other than tea. As a continuation of this study, sugars and organic acids occurring in the shoots of Assam, China and Southern forms of the tea plant and of anthocyanins of the latter two, because the Assam variety is devoid of them, have been the subject of an investigation by the chromatographic technique. The following were studied :—

Clone 1.7.1	...	Assam variety.
Sample 128	...	China variety.
Sample 19/22	...	Southern variety (according to Wight).

Sugars.— The sugar contents of the three varieties are given below :—

Clone 1.7.1 :	Glucose, mannose, arabinose, maltose and inositol.
Sample 128 :	Glucose, galactose, mannose, fructose, arabinose, xylose, ribose, rhamnose, sucrose and inositol.
Sample 19/22 :	Glucose, galactose, mannose, fructose, arabinose, ribose, sucrose, raffinose and inositol.

Maltose is present only in the Assam variety but no galactose, ribose and fructose or fructose containing di- and tri-saccharides, sucrose and raffinose, which may be its characteristic features. To establish it, study of a few more forms of the variety is no doubt necessary. Rhamnose is present only in the China variety. It may be noted that rhamnose containing two flavonol glycosides, kaempferol-3-rhamnodiglucoside and quercitin-3-rhamnodiglucoside, are characteristic of the China variety and are absent, or nearly so, in the other varieties.

Organic acids.— A preliminary investigation of the organic acids of the three varieties showed the presence, from the spots in chromatograms, of about six acids, two, possibly tartaric and citric acids, being in good amounts. Oxalic acid, particularly in the presence of other acids, streaks down the chromatograms with variable results and as such, its presence in the extracts, though characteristic (as calcium oxalate) of tea, could not be confirmed. It is hoped that complete separation of the acid mixture will be possible either in silica gel or ion exchange columns.

Anthocyanins.— The leaf of the China variety was found to contain three anthocyanins. The aglycone of the one with lowest Rf value is delphinidin, while cyanidin is one of the other two. The sugar moiety of all the three is arabinose which is attached to different positions in the aglycone ; the positions of the glycosidic linkage are not known yet. The Southern variety showed the presence of two anthocyanins, which are also arabinosides of cyanidin and delphinidin.

Volatile Substances :

The extraction of volatile matter of tea without any change presented a difficult problem which considerably hampered the progress of the work on them. The steam distillation method, both with and without pressure, and also direct extraction by solvents were not successful. The use of specially purified petrol ether (100°—110°C) containing about 10% pure ether has of late been found to be useful in extracting the volatile matter from an infusion.

By this method, the volatile matter of about 10 lbs. flavoury second flush Darjeeling tea (F.O.P.) has been extracted, and the extract used for the preparation of 2, 4-dinitrophenyl hydrazone derivatives of the carbonyl compounds. The mixed hydrazones on a column of neutral alumia with a mixture of benzene and chloroform in different proportions as a developer gave three main bands. The most rapidly moving yellow band was collected in a number of arbitrary fractions. Each of these and the two top ones, extruded from the column and later eluated with alcohol, will be studied on paper chromatograms to test their homogeneity and rechromatographed on column for further separation, if necessary.

A preliminary investigation indicated the presence of two alcohols also in very small amounts in the extract.

Chemical Basis of Quality :

This investigation which has been in progress since 1956, aims at establishing a correlation between chemical constituents of leaf and made tea and the liquor characters of the latter as judged by the tasters.

Previous years' results had indicated that a high content of water-soluble solids, polyphenols and caffeine in fresh leaf along with a higher concentration of the oxidising enzyme were a desirable feature of the fresh leaf and in general a higher content of Theaflavins and Thearubigins was associated with desirable attributes of made tea.

In 1958, the study was confined to the following six sources of leaf only:

(1) Clone 20.23.1.

(2) Clone 19.29.13.

(3) Dranjuk (A × D and A × E mixed).

(4) Betjan.

(5) Singlo

(6) Mesai Manipuri.

As it was not possible to analyse and manufacture all these samples in a single day, they were divided into two groups which were plucked on different days of the week. Briefly the work involved manufacture, both orthodox and C.T.C., chemical analysis of important constituents of green leaf and made tea (only orthodox manufacture) and tasting of teas against Betjan as a standard.

Chemical analysis of fresh leaf involved the following estimations :

(1) Inorganic constituents such as K_2O, P_2O_5 and Ca.

(2) Total water-soluble solids.

(3) Total nitrogen, total soluble, nitrogen, caffeine nitrogen and amino acid nitrogen.

(4) Pectin as Ca pectate.

(5) Total polyphenol and

(6) Polyphenol oxidase activity.

Black teas (orthodox manufacture) were analysed mainly for the following :

(1) Water soluble solids.

(2) Total nitrogen, total soluble nitrogen, caffeine nitrogen and amino acid nitrogen.

(3) Polyphenols.

(4) Steam volatile matter.

(5) Condensation Index.

(6) Polymers.

Chemical analysis for C.T.C. was limited to the estimations of Condensation Index, Theaflavins and Thearubigins.

Samples were sent to the tasters under code numbers in triplicate (each having a different code) for their remarks and evaluation on standard Tocklai Tasting Forms. After a lapse

of a couple of weeks, samples were again sent in triplicate this time under a different code marking. Thus every sample was evaluated by the tasters six times. Quite frequently the tasters could tell that they were evaluating the same tea in triplicate or that they had tasted that sample previously.

Betjan was used as a standard (50 marks for each character) and was sent in triplicate to the tasters. The tasters were aware of only one of the sample of Betjan as being the standard and the other two samples of Betjan were evaluated by them relative to this standard like any other sample. Consequently, the average of these marks for each liquor character for Betjan is not always 50 (see table 1) though close to it.

Despite relatively large differences in the marks of replicates and also between the marks of the two tasters, there was a good area of agreement between the two tasters when average figures for individual characters and valuations were considered.

In the following table (Table 1), average figures are recorded for some important chemical ingredients of both leaf and made tea, along with tasters' marks and valuations.

The two tasters are in *full agreement as to the choice of the best and the poorest quality teas.* Thus made tea from *clone 20.23.1 comes in the 1st order of preference and Dranjuk as the last.* Some of the high lights of the statistical analysis are given below :—

There was near unanimous agreement as to the role of Qo_2 in determining the liquor characters. According to the findings of both the tasters there is a positive correlation (significant at .01% level) between Qo_2 and infused leaf and colour of the liquor. There was also a positive correlation between this factor and strength and briskness (significant at 1% and 5% levels respectively). Similarly a positive correlation has been found between the product of Qo_2 and % total polyphenols and appearance of infused leaf, colour, strengths and briskness of the liquor.

		Betjan	Singlo	Mesai Manipuri.	20-23-1	Dranjuk	19-29-13.
Fresh Leaf	Water sol solids	49·8	51·0	49.5	50.1	50·1	48.8
	Total Polyphenols	33·1	34·4	33.0	33.3	32·2	34.2
	Qo_2	23·4	21·9	22.1	25.8	22·1	25.3
	Qo_2 × polyphenols	778	755	734	857	710	862
	Total nitrogen	4·66	4·47	4.58	4.47	4·44	4.00
	Total soluble nitrogen	2·08	1·95	2.02	1.99	1·95	1.70
	Caffeine	4·15	4·07	4.04	4.60	4·09	4.12
Made Tea (Orthodox)	Condensation Index	33·8	29·3	32.0	37.0	32·9	42.7
	Total nitrogen	4·94	4·75	4.87	4.75	4·66	4.24
	Total soluble N.	2·45	2·35	2.36	2.32	2·27	2.00
	Theaflavins	·350	·304	.316	.365	·318	.348
	Thearubigins	1·10	0·979	1.120	1.229	1·098	1.328
	Distr. Co-efficient	·394	·398	.408	.424	·434	.438
Tocklai Taster's Mark (Orthodox)	Infused leaf	47	45	37	58	33	48
	Colour	47	35	39	55	44	55
	Strength	51	37	41	74	42	57
	Quality	50	37	37	51	33	43
	Briskness	50	46	46	56	44	49
	Valuation (Rs.)	2·74	2·49	2·54	2·92	2·46	2·70
I.T.C.L. Taster's marks (Orthodox)	Infused leaf	51	43	45	73	49	67
	Colour	51	40	43	58	45	57
	Strength	50	49	52	63	47	63
	Quality	49	49	42	58	44	46
	Briskness	49	50	50	54	47	60
	Valuation (Rs.)	2·59	2·54	2.49	2.75	2·42	2·70
Made Tea (C.T.C.)	Condensation Index	51·2	45·8	51.2	42.2	44·0	56·6
	Theaflavins	0·643	0·631	0.594	0.707	0·596	0·618
	Thearubigins	2·232	2·100	2.173	2.237	2·243	2·541
	Distr. Co-efficient	0·468	0·495	0.476	0.509	0·501	0·487
Tocklai Taster's marks, (C.T.C.)	Infused leaf	50	47	43	54	38	53
	Colour	47	43	42	52	45	57
	Strength	49	47	46	73	50	50
	Quality	48	43	38	58	31	54
	Briskness	50	51	48	61	45	56
	Valuation (Rs.)	3·70	3 62	3.50	4.09	3·42	3·93
J.T.C.L. Taster's marks. (C.T.C.)	Infused leaf	51	47	46	70	56	70
	Colour	49	46	45	58	48	63
	Strength	49	49	49	67	52	72
	Quality	48	49	45	63	49	50
	Briskness	49	51	47	58	45	64
	Valuation (Rs.)	3·58	3·45	3·45	4·13	3·95	4·00

Both the tasters agree that there is a positive correlation between theaflavin content of tea and the colour of liquor as well as the appearance of the infused leaf. Similarly a correlation has been found between thearubigin content and colour. However, there is some disagreement between the tasters in respect of the correlation between theaflavins and thearubigins contents and other characters of liquor. Organoleptic tests by the tasters confirm that there is a correlation between Condensation Index and colour.

Neither of the testers found any correlation between the liquor characters and total polyphenols (Lowenthal). Similarly no correlation has been observed between water-soluble solids (in 1 hr. infusion and in the coarse mince) and tasters' cup-characters.

As far as the individual liquor characters are concerned, the tea tasters are not always in agreement. In fact, statistical analysis conclusively brings out the fact that either some of the liquor characters mean different things to different tasters or that the thresholds in respect of these characters may be different. Thus, for example, one of the tasters consistently finds a positive correlation between nitrogen in all forms (total nitrogen, total soluble nitrogen etc.) and briskness whereas the other taster does not find any such correlation.

In case of C.T.C. teas where only limited data could be collected, it has been found by both the tasters that colour and quality of tea are related to its theaflavin content and thearubigin content is related to the colour of the liquor. Further, it was confirmed by both the tasters that no correlation exists between thearubigin content and quality and briskness.

Full results of last three years experiments will be compiled as a separate memo from this department.

Carbohydrates of Tea :

A systematic investigation has been undertaken on the carbohydrates of tea including pectins. Reported literature on this subject is scanty and our knowledge of the role played

by this group of compounds in determining the quality of tea is limited. The object of this project is to find out the nature of carbohydrates present in leaf and the changes undergone by these constituents during the various stages of manufacture.

Simple Carbohydrates of green leaf and Black tea.— Preliminary work was carried out to standardize the conditions under which the carbohydrate fraction (sugars and oligosaccharides) could be separated from the other chemical constituents and colouring matter etc. It has been established that colouring matter and polyphenols can be largely eliminated by precipitation of the aqueous infusion of leaf with lead acetate and removal of the latter by treatment with H_2S. The clarified solution containing the soluble carbohydrate matter was analysed by paper partition chromatography using butanol : acetic acid : water (4 : 1 : 5) as the solvent and benzidine-trichloroacetic acid, urea oxalate and aniline oxalate as the spray reagents. Besides the usual sugars, sucrose, glucose, fructose and pentoses, a few spots were also noticed having lower Rf's than sucrose. By hydrolysis of the separated, but unsprayed spots *in situ* it was shown that the spot immediately below sucrose (lower Rf.) contains only glucose and fructose residues.

Preliminary experiments using a charcoal-celite column for separation of these sugars have yielded encouraging results and it is felt that before long it will be possible to get the oligosaccharide fraction separated from the other sugars.

It has been found possible to prepare the oligosaccharide fraction by an alternate method. The alcoholic solution obtained after precipitating out the pectins (see next para) on concentration and precipitation with alcohol separates out the oligosaccharides contaminated with mono- and disaccharides.

A comparison of the intensities of sprayed spots of sugars from green leaf and black tea revealed that there was a marked decrease in the concentration of sucrose in the latter relative to the former. In connection with this work we undertook a study of the enzyme system of green leaf and established the

presence of invertase. Thus the decrease of sucrose during manufacture reported above is understandable.

(ii) **Pectins.**— No work has previously been reported from these laboratories regarding the nature of pectin from tea. In as much as, it is generally believed that pectin plays some role in determining the quality of tea, it was decided to undertake this investigation with the triple purpose of finding out its chemical nature, the changes undergone by it during manufacture and its role in determining the quality of made tea. Recent work from Ceylon Tea Research Institute had indicated that an enzyme present in tea causes the demethylation of pectin molecules of tea leaf during fermentation.

Pectin was prepared by boiling tea leaf with hot water and precipitating it by step-wise addition of alcohol. Fractions were collected consisting of the precipitates obtained at concentrations of 40, 50, 75 and $87\frac{1}{2}\%$ of alcohol (v/v). The average yield of all the four fractions was 2.0% based on the weight of dry leaf. Pectins were prepared from fresh leaf, withered leaf and fermented leaf. Preliminary examination of the pectins prepared as above indicated that their aqueous solutions were only slightly acidic and the titre with N/500 $Ba(OH)_2$ using phenolphthalein was so small that no distinction could be made between these pectins from different sources.

Acid hydrolysis of pectin yielded arabinose, rhamnose, galacturonic acid, glucose and galactose. These compounds were identified chromatographically. The liberation of these carbohydrates does not proceed simultaneously but rather successively. Under milder conditions of hydrolysis it was possible to preferentially knock out the pentoses without much affecting the glycosidic linkages of pectin. Thus when pectin was hydrolysed with $\frac{1}{2}\%$ H_2SO_4 in 95% alcohol for $3\frac{1}{2}$ hours, only arabinose was detected in the hydrolysate. This selective action of a mild hydrolysing agent indicates the presence of either a large amount of non-pectic ballast materials (pentosans) or less likely the presence of pentose residues in the pectin molecule itself. Alternatively, there could be artifacts produced from acid. We have also observed the presence

of pentoses in the enzymic hydrolysates of pectins. Quantitative estimations of the product of hydrolysis have been started with the object of following the process of purification.

Typical relative intensities of various spots as measured spectrophotometrically are given below:—

			Optical density.
1.	Galacturonic acid	... ...	0.10
2.	Galactose and glucose	... ...	0.45
3.	Arabinose	... ...	0.13
4.	Xylose	... ...	0.06
5.	Rhamnose	... ...	0.14

Hydrolysis of pectin by the washed enzyme is in progress. Incubation of tea pectin with washed enzyme results in the production of methyl alcohol indicting pectin methyl esterase activity.

Estimation of Polyphenols in Tea :

Reberts *el al.* have investigated the changes undergone by polyphenols of tea leaf during fermentation by qualitative paper partition chromatography. As a result of their work it has been concluded that the major changes taking place during fermentation pertain to l-epigallocatechin and l-epigallocatechin gallate. According to the authors the end products of oxidation are theaflavins and thearubigins. As these oxidation products of polyphenols are related to the quality of tea, study of factors relating to their formation is of obvious importance. It is now felt that for a more comprehensive understanding of fermentation process we should have a method for the estimation of polyphenols of tea. A knowledge of the concentrations of various polyphenols at definite intervals of fermentation, will aid in arriving at an interrelation of these changes.

It is intended to base the method on the colorimetric estimations of polyphenols extracted from chromatograms

before spraying. In a preliminary survey the following reagents were tried :

(i) $FeCl_3$ with Na-K-tartrate.

(ii) Ferric alum with Na-K-tartrate.

(iii) $FeSO_4$ with Na-K-tartrate.

(iv) 1% vanillin in conc. HCl.

(v) 1% vanillin in conc. H_2SO_4.

Vanillin in sulphuric acid reagent seemed to be promising, and subsequent experiments were conducted with it. Water, ethanol of various strengths, methanol, acetone and ethyl accetate were tried for extraction of polyphenols. Of these only water and 50% alcohol were found to be suitable.

In a typical experiment the extract was concentrated to 2 cc. over water bath and 3 cc. of 1% vanillin in conc. H_2SO_4 was added. The intensity of the colour developed was measured using an Absorptiometer. Results are given below :-

Table 2.

Wave-length.	Epi-Catechin gallate.	Epi-gallo-catechin.	Epi-Gallocatechin gallate.
465	.167	.340	0.690
470	.171	.352	.700
475	.175	.363	.720
480	.178	.375	.740
485	.178	.378	.745
490	.178	.380	.750
495	.178	.380	.760
500	.178	.380	.760
505	.175	.380	.762
510	.175	.372	.768
515	.170	.365	.768
520	.166	.355	.765
530	.160	.328	.760
540	.142	.288	.730
550.	.133	.250	.700
560	.125	.218	.660
570	.113	.182	.608
580	.105	.160	.558
600	.095	.125	.470
620	.070	.095	.375
640	.058	.074	.312
660	.050	.064	.260
.700	.035	.045	.186

Subsequent measurements of the colour were done at 500 mμ. In a series of experiments, concentration was carried out on a water bath, under vacuum, at atmospheric pressure, and by bubbling air through the solution during concentration. From the optical density readings, it was concluded that partial oxidation was taking place when concentration was carried out at atmospheric pressure.

Results so far obtained indicate that for success of this method, well defined spots under ultra-violet and concentration under vacuum are the two minimum requirements. The method has been found applicable for the estimation of Epi-gallocatechin, Epi-gallocatechin gallate and Epi-catechin gallate.

MANUFACTURING EXPERIMENTS

Effect of different types of Water used for washing the rolling machinery and fermentation floors on the Colour of made tea :

(Jointly with W. Hadfield).

During the last manufacturing season, a number of water analyses were received for report on their suitability for washing the rolling tables and fermentation floors. As we had no quantitative data on the effect of iron content, pH, temporary and permanent hardness of water on the colour and quality of made tea infusions, an experiment was devised to get such data.

Solutions were made containing :

(*a*) differing concentrations of iron in the form of ferrous sulphate.

(*b*) varying amounts of sodium hydroxide, sodium bicarbonate, calcium bicarbonate, magnesium sulphate and acetic acid.

(*c*) mixtures were made of solutions from (*a*) and (*b*) in order to find the effect of iron of various pH values.

Comparable samples of leaf were manufactured by Pizey manufacture, the rolling tables being washed with the various solutions, and after rolling the fermenting trays also being

washed. In each set of samples, a control sample was used, the rolling table and the fermenting tray being washed in distilled water.

After firing the samples were infused and the infusion tested for thearubigins and theaflavins contents by the spectrophotometer and by the tintometer method. The total theaflavins and thearubigins were estimated and the ratio $\frac{TF}{TR}$ calculated from the results.

The remainder of the leaf was used to make infusions and the liquors were examined by the Tocklai Tea Taster for differences in colour (if any). Results are recorded in table I to IV.

Table I : Effect of Iron.

Amount of iron.	Nil (control)	2.5 ppm.	5·0 ppm.	10 ppm.	25 ppm.	50 ppm.
pH of Soln.	7	6.5	6.5	5.8	5.4	5.58
Theaflavins	0.60	0.62	0.60	0.58	0.66	0.57
Thearubigins	1.43	1.46	1.32	1.41	1.50	1.26
TF/TR	0.42	0.42	0.45	0.41	0.44	0.45
Taster mark for colour	5	5	5	6	6	3

Table II : Effect of pH.

Substance used	Acetic acid 5mgs/litre.	NaOH 100 mgs/ litre.	$NaHCO_3$ 100 mgs/ litre.	Control.
pH of Soln.	3.6	9.6	8.0	7.0
Theaflavins	0.564	0.490	0.556	0.584
Thearubigins	1.702	1.250	1.569	1.636
TF/TR	0.331	0.392	0.354	0.357
Tasters Mark for colour	6	3	5	5

Table III : Effect of Iron at different pH values.

Amount of Iron.	25 ppm.	12.5 ppm.	2.5 ppm.	25 ppm.	12.5ppm.	2.5ppm.	Control
pH of Soln.	8.2 (NaOH)	9.0 (NaOH)	9.2 (NaOH)	7.7 ($NaHCO_3$)	7.7 ($NaHCO_3$)	7.7 ($NaHCO_3$)	7.0 (H_2O)
Theaflavins	0.46	0.50	0.52	0.57	0.60	0.64	0.590
Thearubigins	1.08	1.22	1.22	1.31	1.46	1.42	1.45
TF/TR	0.425	0.411	0.426	0.435	0.410	0.451	0.407
Tasters Mark for colour	1	4	3	3	4	4	5

Table IV. : Effect of Hard Water.

Nature of Hardness	Temporary $Ca(HCO_3)_2$	Permanent $MgSO_4$ (10 ppm)	Control.
pH ...	6.21	7.09	7.0
Theaflavins ...	0.60	0.456	0.584
Thearubigins ...	1.66	1.65	1.636
TF/TR ...	0.360	0.276	0.357
Tasters Mark for colour ...	5	3	5

In considering these results the total values for both theaflavins and thearubigins should be considered as well as the ratio of these substances, as a decrease in both does not necessarily alter the ratio.

(1) *Effect of Iron* : Iron alone does not have a noticeable effect on colour until a concentration of 25 parts per million is reached, and at 50 p.p.m. the effect is marked. These concentrations are not usually found in normal water supplies, and under normal conditions the iron content of water should not cause any trouble in manufacture.

(2) *Effect of pH* : At highly alkaline pH values the colour is considerably decreased, the thearubigins content being especially affected in the case of adding sodium hydroxide to water.

At highly acidic pH values the colour is increased slightly, the effect being due to an increase in thearubigins rather than theaflavins.

At the range of pH 6—8, which is the range usually found in the tube well water there was no obvious effect on colour.

(3) *pH and Iron interaction* : At alkaline pH's the effect of iron becomes more pronounced *i.e.* loss of colour is found at less alkaline pH's, while at acidic pH values the effect of iron is less pronounced. At pH of 9.2 iron at a conc. of 2.5 p.p.m. has a markedly deleterious effect on the colour of tea infusions.

(4) *Hardness of water* : Permanently hard water has a markedly depressing effect on colour, the theaflavins being most affected , while temporarily hard water has no effect. This is likely to be of considerable importance under commercial conditions.

In terms of the advisory work being carried out by the Biochemical Branch these results mean that we are now in a better position to state whether or not the water being used in a factory is likely to affect the colour of made teas. From the majority of water analyses received in the labaratory the iron content and pH are within the range where little or on deleterious effect may be expected, but rather surprising results obtained from the permanently hard water experiment suggest that further experiments on this are desirable.

More carefully controlled experiments using various types of water to make up infusions are likely to give more fundamental information on the effect of these water impurities on theaflavins and thearubigins and other liquor characters of made teas. These experiments will be conducted during the current year.

SCIENTIFIC PUBLICATIONS

Paper Chromatography as an Aid to the Taxonomy of Thea Camellias—E.A.H. Roberts, W. Wight and D. J. Wood, published in the New Phytologist, 57, 211-225, July, 1958.

Chemistry and Technology of Tea—I.S. Bhatia, sent for publication to the Journal of Assam Science Society.

A paper on "Experiments relating to the Development of Controlled Withering Machines" presented by I. S. Bhatia at the Annual Conference, Tocklai.

Instructions for using the 'Kaybee' Infra-Red Moisture Tester type X—14 with tea—D. J. Wood and N. B. Chanda, published in Two and a Bud, Vol. 5, No. 3, 1958.

Encylopaedia Serial entitled "Degree of Wither and Its Effect on Firing"—D. J. Wood and N. B. Chanda (in press).

ADVISORY

Correspondence.— During the year 91 letters of an advisory nature were issued.

Touring.— The Senior Biochemist visited Kakajan T. E. on 26.11.56. He also visited Gauhati from the 19th to 22nd December in connection with the Annual Meeting of the Assam Science Society and presented a paper on the Chemistry and Technology of Tea Manufacture.

The Biochemist visited in April/May the following tea estates in Darjeeling and Dooars :

Soom, Ging, Lingia, Tukvar, Happy Valley, Nagri-Farm, Hope, Nagrakata, Looksan and Nya-Sylee.

BIOCHEMICAL BRANCH—TEA TASTING SECTION

J. M. Trinick—Tea Taster.

STAFF

There were no changes in staff during 1958. Mr. Trinick was on sick leave from 2nd to 9th September, 22nd to 30th September, 27th to 30th October and 25th November to 6th December. He proceeded on U.K. leave on 10th December.

TASTING

During the year the following samples were tasted:

For Tocklai Experimental Station	...	2,023
For Member Estates	...	7,473
For Non Member Estates ...	...	107
		9,603

This represents a marked increase over previous years.

ADVISORY

Touring.— In addition to numerous visits to Nagajanka T. E. in connection with commercial Rotorvane trials, the Tea Taster visited the following estates in connection with tasting and manufacture.

Assam member estates:

Cinnamara, Bokakhat, Katonibari Dhoolie, Koomtai, Tyroon, Heeleakah, Duklingia, Teok, Kakajan, Namroop, Borhat, Dessoie, Nahortoli, Mothola, Balijan North, Mohanbari, Napuk, Murmuria, Kharikatia, Sycotta, Joonktollee, Meleng, Behora, Tezpur Gogra and Cherideo Purbat.

Several of these estates were visited on more than one occasion.

Cachar member estates :

Dilkoosh, Bortoll, Dewan, Labac, Silcoorie, Aenakhall Pallorbund, Majagram, Doyapore, Subong, Hatticherra, Bhubandhar, Kalline and Koyah.

Courses.— The Taster gave three lectures on Withering, Rolling, Fermenting, Firing, Sorting and Packing, at the three general lectures courses held during February and March. The Taster also delivered a paper entitled "Some Points on The Manufacture Incorporating Modern Machinery" at the Annual Conference in November.

Advisory Correspondence.— 558 letters of an advisory nature were issued during the year.

GENERAL REMARKS

There was an increase in 1958 in the number of requests for advice on manufacturing problems, which accounts for the increased touring undertaken.

The Tea Taster also co-operated with the Research Engineer on work connected with the commercial trials of the Rotorvane. This also involved a considerable amount of touring.

The increase in the number of samples tasted was partly due to co-operation with the Selection Officer, in tasting clonal selections from member gardens. These samples were tasted in less detail than is normal so that a larger number could be dealt with.

ENGINEERING DEVELOPMENT BRANCH

I. McTEAR—Senior Research Engineer.

D. N. BORBORA—Research Engineer.

STAFF

No changes took place during the year.

RESEARCH AND EXPERIMENT

Mechanical Harvesting :

The Machine.

The machine operated throughout the season without modification. In general little or no mechanical trouble was experienced with the machine which operated in a satisfactory manner.

The season under review saw the introduction of larger size cutter blades for the cropping mechanism. These blades are of wider pitch than any of the sets previously fitted and would appear to have sufficient capacity to deal with vigourous flushes ; a feature which was lacking with the earlier blades in use.

Although the new wheel equipment, intended to be fitted to the rear-end of the machine arrived during the season, it was not possible to interrupt the working of the vehicle. This can only be taken in hand after harvesting and pruning operations are completed for the season.

Harvesting of Leaf.

The design of the experiment was similar in pattern to that of the previous season, arranged in the following manner:—

A— 8 Rows of tea bushes which were hand pruned and plucked; tipped at 8-inches on a 7 day round.

B— 8 Rows of tea bushes machined pruned and harvested; tipped at 6-inches.

C— 8 Rows of tea bushes machined pruned and harvested; tipped at 4-inches.

Each row contained 100 bushes and the hand plucked rows were randomised with machine harvested rows in blocks. Thus the effect of soil and cultural conditions could be eliminated.

The procedure decided upon during the period of harvesting was to raise the harvesting level by $\frac{1}{4}$ inch each round but to limit such rounds to growth conditions. This had the twofold object calculated (*a*) to minimise the percentage of coarse leaf and (*b*) to reduce the incidence of mechanical damage respectively.

Early in the season the idea certainly seemed to prove beneficial, because, up to the end of the second week in August, total yield from both 'B' and 'C' rows had been in advance of 'A' rows, with however rows 'C' showing a marked improvement over rows 'B' both in yield and reduced percentage of coarse leaf and as experienced during Season 1957.

From mid-August growth of new shoots slowed down considerably in all three treatments (in fact this state of affairs was general for the District). Although hand plucked rows were depressed in yield the effects were more pronounced in the machine harvested rows.

Growth recovery was reached in the hand plucked rows by the 8th September, some 21 days after the rate of flushing became retarded. By comparison the mechanically harvested rows remained dormant for a period of some 28 days before yield reached average proportions for the time of the year. Thereafter the yield pattern was similar to the hand plucked rows 'A', although there was a significant reduction in crop from the mechanically harvested rows 'B' and 'C'.

The procedure adopted coupled with results obtained, and, by no means insignificant, the condition of the mechanically harvested tea compared with the hand plucked rows indicate that increase in the harvesting level might be of a restricted nature, which should result in a reduction of the dormant growth which is always noticeably more prominent in the mechanically harvested rows.

That the yield and quality of the leaf harvested from rows 'C' (4 inch tipping) was again an improvement over results obtained from rows 'B' (6 inch tipping) would seem to accentuate what is considered to be the reason for the gradual reduction in yield of the mechanical harvested rows as the season progresses *i.e.* the number of new leaves on the harvesting table is considerably in excess of that found in the hand plucked sections. This condition undoubtedly retards the growth of manufacturable shoots (two and a bud), and is quite clearly shown in the comparison between the 4-inch and the 6-inch tipping levels. Even so, the 4-inch tipping level, coupled with the raising of the harvesting table by ¼-inch each round produces new leaf growth in excess of hand methods of plucking.

Results of the above nature have been experienced over two seasons, and this gives fairly definite support to the measures proposed for future observations, whereby the raising of the harvesting level will be regulated with a view to maintaining a balance between new leaf growth left unplucked over the tipping height and a condition favourable for stimulating growth of manufacturable shoots.

Manufacturing Trials.

In order to obtain a comparison between leaf which is hand plucked as well as machine harvested, from the test section at Borbhetta, manufacturing trials were conducted to coincide with harvesting rounds. Similar methods of manufacture applied for both varieties of leaf. The outcome of Taster's valuations, comprising a full seasons observations, has resulted in a general average in favour of hand plucked leaf amounting to 15.4% better prices compared with mechanically harvested teas. London valuations for hand plucked were 11.5% higher; Calcutta 18% and Tocklai 16%. When considering these differentials it must be stressed that the standard of Borbhetta hand plucked leaf is rarely attained with commercial plucking standards.

Withering :

The Continuous Withering Machine, designed and fabricated in the U.K., arrived at Tocklai towards the close of 1957 and was installed in the Pilot factory during the early part of the year.

Several preliminary withering tests were conducted on leaf from commercial sources with a view to testing-out the mechanical system employed for conveying the leaf through the chamber and the operation of the Peabody direct heater, which is used to condition atmospheric air for the specific requirements of withering.

At the conclusion of the preliminary tests, during the course of which it became obvious that the circumstances prevailing at Tocklai were too limited in scope for comprehensive testing, it was arranged, through the good offices of The Jorehaut Tea Co., Ltd., to install the machine at Cinnamara factory.

Transfer of the machine and subsequent assembly was completed during the month of November which necessarily curtailed further testing to the closing weeks of the manufacturing season when leaf and climatic conditions are not really representative of factors prevailing when the main bulk of the crop is manufactured.

After experimenting with various process speeds to suit the wither requirements of C. T. C. manufacture the timing through the chamber which provided suitably withered leaf, proved to be 2 hours 15 minutes, whilst the condition of the inlet air to the leaf was generally maintained at an hygrometric difference of 18°F. General atmospheric conditions prevailing were such that relative humidity was about 84%.

The physical wither obtained was very good indeed and superior in average wither appearance to similar leaf withered under natural conditions in chung buildings.

The fact that leaf withered in the continuous machine is not subjected to so much handling as is customary with leaf withered even under the best of natural conditions must prove

of considerable benefit to the finished teas over a season's operations.

It will be remembered that heat generation for the continuous withering machine is by direct products of combustion to which is admixed atmospheric air. The system is undoubtedly ideal from many points of view; prominent amongst these is the speed with which suitable working temperatures are attained and maintained relative to conditions of the atmosphere.

Continuous Rolling and Processing Machines:

The two machines which have been under investigation and development are (*a*) The Rotorvane and (*b*) Continuous Roller No. 2. In the design of these machines the approach has been directed towards specific purposes calculated to process leaf according to current market requirements; in which connection the Rotorvane, as developed to-date, does not aim at processing leaf from which whole-leaf grades may be obtained. Thus the main purpose of the Rotorvane is to impart a vigorous action to the leaf so as to effectively damage leaf cells, which seems to be the basis for colour liquors. A machine which works on this principle must necessarily over-process tip resulting in almost total elimination of the effects which machines of different action are capable of retaining as regards appearance of the dry leaf.

The Rotorvane.

The introduction of the Rotorvane on a limited commercial manufacturing scale and its subsequent operation in various factories has provided much valuable information that enabled a better understanding of processing leaf under commercial manufacturing conditions. As a result some modifications have been made possible and these generally have been of a successful nature.

Although in general design the mechanism of the machine is simple it lends itself to a number of detailed changes over a fairly wide range of aspects. Most prominent is perhaps the size and surface configuration of the inter-stage cylinder resistors.

Because of facilities available a number of various pattern resistors have been tested out during the manufacturing season in a commercial factory and this resulted in a certain type and size of resistor which achieves results considered to be quite favourable. The current production series of Rotorvanes incorporate these features.

That the new type resistor has proved successful opens up additional possibilities for the future design of these machines with perhaps further simplification. These modifications are being incorporated in the Tocklai built Rotorvane and will be available for operation under commercial factory conditions during the forth-coming season.

Continuous Roller No. 2.

This machine has been developed primarily for processing conventional teas. This implies that it should produce whole-leaf grades as well as preserve tip to much the same standards as set by the three-crank batch rolling machine.

In the development of a machine of the type under review a considerable number of parallel manufacturing tests must necessarily be undertaken to observe whether the effects produced match-up to a high standard in leaf appearance. That this standard has been reached, if not exceeded, is reflected in the results obtained during the year under review when valuations for teas processed in the continuous machine were generally higher than those manufactured by the conventional two-roll system involving 2×40 minute rolls.

The intensity of the processing action to which it is possible to subject leaf to produce conventional graded teas of good appearance is one that requires close study and it has been for this reason that manufacturing trials have been of special significance.

During the course of these trials changes have been made to the machine to alter certain mechanical features concerned with introducing an increased degree of positiveness to leaf travel through the machine as opposed to attempting the same thing by means of a specially contoured trough surface. Having

brought about the desired effect mechanically makes possible a more favourable trough surface which will intensify processing but not, it is hoped, at the expense of any falling-off in leaf appearance. What this new surface aims to achieve is nothing more than making the action imparted to the leaf similar on the back-stroke as it presently is on the forward-stroke of the trough. Thus the processing time in the machine to bring about the desired results will be much reduced.

It is considered that Continuous Roller No. 2 should be capable of a desirable degree of processing within one pass through two machines, arranged in series, and it is towards this desirable end that the concluding stages in the development of the machine are directly concerned.

Fermenting and Drying Machines :

In view of the favourable results obtained during investigations into drying tea by a continuous alternating tray machine, which mechanical and tray motion system is also suitable for the fermentation of leaf, it is appropriate that these two stages in manufacture should be considered in conjunction since the system and sequence of operations fit well together.

For the purpose of this investigation a small prototype drying machine was fabricated the main features of which briefly concern :—

(*i*) A drying chamber which is both compact and very much simplified compared with existing types.

(*ii*) Leaf on the trays is undisturbed during passage through the entire process of fermenting and drying.

(*iii*) Intermediate manual handling of leaf after rolling is automatically eliminated.

(*iv*) Airflow through the drying stages can be regulated to specific requirements best suited to drying tea.

The machine used to conduct these tests was confined to the drying process since factors involved in drying of tea are more exacting than fermentation where some latitude, within limits, is permissible.

From the restricted nature of the tests conducted with this new type drier in comparison with tea dried in a conventional dryer (Tilting tray type) Tasters reports indicate a decided preference for the new dryer tea. As usual in comparisons of this kind parallel manufacture is implied. The distinction is strictly confined to the method of drying the tea.

A feature of this new type Dryer which has constantly been in evidence during comparative drying tests has been an additional degree of blackness in the dried leaf when compared with similar leaf, simultaneously processed, but dried in a conventional perforated tray dryer. This additional blackness of the dried leaf is common to both Conventional grade teas as well as C.T.C. method of manufacture.

That these drying tests were, as far as the new type machine is concerned, purely exploratory in character is a further point in favour of this method of drying tea.

The information obtained and the general functioning of the prototype machine having served the purpose of initial investigation will now be re-built to a higher standard of workmanship to permit a full examination of airflow requirements and other aspects associated with its various functions.

Tea Drying by Direct Combustion Heat:

Several comparative drying tests were undertaken to measure Taster's reactions to teas dried by this method.

The apparatus used was a small tray drier attached to the by-pass to atmosphere of the Peabody direct heater coupled to the Continuous Withering Machine.

Tasters were unable to detect any evidence of taint whilst the general trend of opinions on teas submitted, dried by both indirect and direct methods, was in favour of the direct heater dried tea.

STATISTICAL BRANCH

A. R. SEN—Senior Statistician

ORGANISATION AND STAFF

The Senior Statistician was mainly engaged in the task of organising the branch, which actively came into being with his joining the Experimental Station in March, 1958.

As organised at present, the functions of the branch are (*i*) Advisory—to assist other branches in the planning of their field experiments, (*ii*) to prepare critical and comprehensive summaries of bodies of data, more related to practical issues and (*iii*) to plan and organise, in co-operation with the branches concerned, sampling enquiries and co-ordinated experiments in the gardens, directly or indirectly related to Engledow Commission recommendations.

Shri K. C. Jaiswal joined the branch as a Stenographer on 1st April, 1958. Shri Ajit Kumar Biswas joined duties as Statistical Assistant on 7th July, 1958. Shri Arup Ratan Sarkar has accepted the offer for appointment as Statistical Assistant and is expected to join during the first week of January, 1959. The services of Shri Robindra Nath Deb were made available to the branch on a temporary basis with effect from 13th August 1958 to attend the increase in work in connection with compilation and analysis of data.

RESEARCH AND EXPERIMENT

Advice of the branch was sought in the planning of experiments on "psyllids" and eelworm control, study of relative efficiency of the various methods of infestation of eelworm and relative efficiency of various nematocides, and on the design of trials on the healing of pruning cuts.

Advice was also sought on the planning of co-ordinated manurial trials and on the design of an experiment with different kinds of shade trees in gardens.

Analysis of data from Fernide trials conducted in various seed baries was done under the direction of the Senior Statisti-

cian. The Senior Statistician also commented on the design and analysis of data from Rotorvane Experiments.

Summarisation of Past Data —Crop Weather Relationship :

The returns showing monthly plucking area, yield per acre, rainfall and temperature from the gardens were scrutinized, compiled and tabulated. Preliminary scrutiny revealed discrepancies in some cases and gaps in most cases. The existing proforma for collection of monthly Crop-Weather data from the tea estates was therefore revised to ensure uniformity in future statements. The revised proforma was circulated to gardens.

Rainfall data from ten gardens for which the series were complete were next subjected to statistical analysis to make a study of the effect of rainfall on yield per acre. For brevity we shall henceforth write 'yield' for 'yield per acre'.

Preliminary investigation started with a search for factors which are highly correlated with yield and finding the appropriate functional relationship of such factors with yield.

Correlations were worked out in the first instance between monthly yield and rainfall averaged over the period for which continuous data are available for the individual gardens. Correlation co-efficients were worked out between yield and rainfall for no lag, lags of one and two months (Table 1).

The average rainfall during a month shows in all cases a high positive correlation with plucking yield in the next month and with the yield in the following month (lag of two months) though there is no significant correlation between rainfall and yield for the same month. The correlation co-efficients with two months' lag are generally higher than correlations with one month's lag but the increases are not significant.

Correlations were also worked out between monthly yield and average temperature (average of maximum and minimum) and also with average range of temperature (maximum minus

Table 1: *Correlations between average monthly Yield and Rainfall with no Lag, Lag of one and two months*

Districts	Circles	Tea Estates	Average for the period	No Lag	One month lag	Two months lag
(1)	(2)	(3)	(4)	(5)	(6)	(7)
Lakhimpur	Doom Dooma	Duamara	1949 - 57	0.3765	0.8022**	0.9417**
,,	,,	Tara	1948 – 57	0.3810	0.8247**	0.9514**
,,	,,	Ananda Bag	1948–57	0.3963	0 8256**	0.9370**
,,	,,	Samdang	1948 57	0.3907	0.8339**	0.9568**
,,	,,	Rupai	1948 – 57	0.5618	0.9061**	0 8552**
,,	Moran	Dirai	1949 – 57	0.4168	0.8573**	0.8970**
,,	,,	Teloijan	1950–57	0.5050	0.9096**	0.9137**
Sibsagar	,,	Hingrijan	1949 57	0.2888	0.7454*	0.9410**
,,	Jorhat	Bokahola	1944–53	0.4068	0.8219**	0.9315**
Terai	Terai	Atal	1948–57	0.5470	0.8583**	0·8699**

* = Significant at 5% level.
** = Significant at 1% level.
SOURCE : Crop Weather Reports submitted by the Tea Estates.

minimum) for a month for seven tea estates for no lag, lags of one and two months (Tables 2 & 3).

The average temperature during a month shows in all cases a high positive correlation with yield in the following month. The average temperature also shows a significant (though less than in case of one month's lag) positive correlation with yield for the same month and with yield after two months, the exception being Atal tea estate in Terai for which the correlation between average temperature and yield for a month was not significant. The correlations for one month's lag are generally higher than correlations with no lag and lag of two months though the differences are not significant.

The average range of temperature during a month is highly but negatively correlated with yield in the following months indicating that an increase in range of temperature is associated with factors unfavourable to crop production. The range of temperature during a month is also negatively correlated with yield during the same month and with yield with two months' lag; these latter correlations are, however, not so high (numerically) as in the case of one month's lag. The distribution of temperature is, however, somewhat different for Atal tea estate where the increase in range of temperature is associated with a more depressing effect on crop production for the same month than on the following crop.

To sum up, on the basis of data from the gardens under investigation it could be said that increase in rainfall during a month is highly associated with an increase in crop two months' later; increase in average temperature during a month has a strong positive correlation with the crop in the following month. Thus for the gardens studied increase in rainfall followed by high average temperature seems to be associated with factors conducive to crop production.

The greater range of temperature during a month, however, appears to be associated with factors unfavourable for tea culture.

It may be mentioned here that the investigation at this stage is only of a preliminary nature and the results are not in any

Table 2 : Correlations between average monthly yield and average temperature with no lag, lag of one and two months.

Districts	Circles	Tea Estates	Average for the period	No Lag	One month lag	Two months lag
(1)	(2)	(3)	(4)	(5)	(6)	(7)
Lakhimpur	Doom Dooma	Duamara	1949–1957	0.7722*	0.9878***	0.7022*
,,	,,	Tara	1948–1957	0.6623	0.9856***	0.8012**
,,	,,	Ananda-Bag	1948–1957	0.7411*	0.9955***	0.7466*
,,	,,	Rupai	1948–1957	0.7749*	0.9896***	0.6904*
,,	Moran	Dirai	1949–1957	0.7502*	0.9919***	0.7242*
Sibsagar	,,	Hingrijan	1949–1957	0.7215*	0.9975***	0.7529*
Terai	Terai	Atal	1948–1957	0.5165	0.8149**	0.7589*

* = Significant at 5% level.
** = Significant at 1% level.
*** = Significant at 0.1% level.

SOURCE : Crop Weather Reports submitted by the Tea Estates.

Table 3: *Correlations between average monthly yield and range* (Maximum—Minimum) of Temperatures with no lag, lag of one and two months.

Districts	Circles	Tea Estates	Average for the period	No Lag	One month lag	Two months lag
(1)	(2)	(3)	(4)	(5)	(6)	(7)
Lakhimpur	Doom Dooma	Duamara	1949-1957	—0·5579	—0·9463***	—0·8606**
,,	,,	Tara	1948 1957	—0·6816*	—0·9679***	—0·7335*
,,	,,	Ananda-Bag	1948-1957	—0 7335*	—0·9751***	—0·7377*
,,	,,	Rupai	1948 1957	—0·6951*	—0·9521***	—0·6802*
,,	Moran	Dirai	1949-1957	—0·7417*	—0·7661*	—0·4577
Sibsagar	,,	Hingrijan	1949-1957	—0·6880*	—0·9426***	—0·6224
Terai	Terai	Atal	1948-1957	—0·8427**	—0·6872*	—0·4111

* = Significant at 5% level.
** = Significant at 1% level.
*** = Significant at 0·1% level.
SOURCE : Crop Weather Reports submitted by the Tea Estates.

way conclusive. These, however, indicate useful line for further study. It is, therefore, intended to examine the problem in some detail and find out if the data show any apparent trends.

Summarisation of Past Data—Garden Experiments:

Summarisation of available information from past experiments in tea gardens has been taken up and a beginning has been made with an examination of past records on design, plot size, jat of tea, treatments, number of replications and coefficients of variation.

Uniformity Trial:

In order to improve the efficiency of field experiments a uniformity trial has been designed on clonal tea in Duklingia tea estate.

The object of the trial is to determine the best size and shape of plot for experimentation with clonal material. It is also intended to utilize the data to determine

(*a*) Seasonal variations and their effect on experimental accuracy;

(*b*) The possibility and value of intermittent plucking in experimentation;

(*c*) The utility of previous crop records as a basis for improving upon the efficiency of experimentation and for forecasting yield, using auxiliary factors like weather etc.

Experimental area

A clone was used and was hedge planted (5′ × 2′) in spring 1952. The soil is loamy with one surface drain and the tea is shaded with *Albizzia odoratissima* with a triangular spacing (36′ × 36′). The shade trees were planted in 1953.

Design of the Experiment

The experimental area consists of twenty columns of seventy-two bushes each. Each column is divided into twelve plots of six contiguous bushes each. Thus there are in all

240 plots, each plot forming an ultimate unit of experimentation. Shade trees are planted in each column after every five columns of bushes and also on both extremities, surrounding the bushes. These columns have, however, been excluded for the purpose of experiment.

Plucking from each of the six bushes constituting a plot was done for 240 plots on each plucking day during the season which extended over 29 plucking rounds.

The five contiguous columns comprising a set were assigned to five pluckers one plucker each to a column. Each of the 12 plots from a column was plucked by a plucker into a basket assigned to the plot with the help of a label indicating the position of the plot in the column and of the column in the set. Weighment continued simultaneously with plucking, the baskets being brought by labourers for weighment immediately after they were full. On completion the pluckers moved to the corresponding set of 5 columns in the same order in which they plucked the first set of five columns and so on till all the twenty columns were covered.

The same order of the plucker was maintained on a few more plucking rounds after which the order of pluckers was changed according to a random arrangement and the changed order continued for a few subsequent rounds, such that a latin square design with five random orders of the five pluckers could be employed. This design would enable the segregation of the variation due to pluckers and their order of plucking from the total variation.

Careful supervision was done (1) to ensure that a labourer plucked from a plot of six bushes only and (2) that a basket had the appropriate label inside it before the commencement of the experiment on each plucking occasion.

In order to bring results deduced from uniformity trials into consonance with modern experimental practice studies are being made of the effect of plots (within blocks) of various sizes and shapes upon standard error and thus obtain a measure of soil heterogeneity by considering appropriate series from the possible types of plot and block combinations. Preliminary

analysis of the results of possible experiments with 2, 3, 4, 6. 12 treatments and plot sizes 36, 24, 18, 12 and 6 bushes per plot respectively are presented below:

Co-efficients of variation (per cent) of plots of different sizes for two different designs.

Number of bushes per plot	Number of treatments	Design	
		R.B.D. *	C.R.D. **
(1)	(2)	(3)	(4)
6	12	19.43	22.53
12	6	16.08	19.41
18	4	13.29	17.15
24	3	12.06	16.07
36	2	9.93	14.52

* R. B. D. = Randomised Block Design.
** C. R. D. = Completely Randomised Design.

For a given plot size the co-efficient of variation for the randomised block design is smaller than the completely randomised design. Also the rate of decrease in error with increase in plot size is higher for the randomised block design than for the completely randomised design.

It is intended to repeat the experiment over a few years to obtain a fair sample of the weather and make a detailed analysis of the data thus obtained to throw light on the problems outlined in the opening para under uniformity trial.

Surveys:

To study the prevalence and seriousness of pests and diseases, the Senior Statistician in collaboration with the Senior Entomologist, the Mycologist and the Senior Advisory Officer Assam designed a pilot sample survey on Pests and Diseases in the districts of Lakhimpur and Sibsagar in pursuance of the recommendations of the Commission of Enquiry on the Scientific Department which met in 1953-54.

A two-stage stratified sampling system with the I.T.A. circle as the stratum, gardens as first-stage units and affected sections as second-stage units has been designed for the survey. Both the gardens and the sections were selected at random.

Two sets of questionnaires were prepared (1) for the gardens—first stage units and (2) for the affected sections—second stage units.

Out of the 31 tea estates selected at random for the first set of questionnaires on Pests and Diseases replies have been received from 27 tea estates.

The second set of questionnaires on a sample of affected sections were of a more detailed nature and information on these are being collected with the help of survey assistants who were deputed to the various circles for the purpose

The survey assistants who had a preliminary training in Pests and Diseases were given a short training on the agronomic aspects of tea cultivation by the Senior Agriculturist. Arrangements were also made with the Scientific Officer, Jorehaut Tea Company for the training of the assistants in answering the questions with the help of registers maintained by the gardens. The Assistants were also given field training in Murmuria tea estate. The data are being received from the gardens on the second set of questionnaires. These will be classified, tabulated and processed to investigate the survey techniques, and assess the value of the data obtained.

The experience on questionnaires, design of survey method of collection of data, and operational set up gathered from the pilot survey will be utilized in repeating the survey next year in some of the selected gardens and extending its scope by including more gardens within the limitations of the field staff available. It is intended to cover the Dooars and other areas.

ADVISORY

Touring— The Senior Statistician visited Calcutta for the interview of candidates in connection with the selection of staff.

He visited the experimental sites at Ghatia, Bhogotpore, Baradighi, Jogeshchandra tea estates in the Dooars and Selimbong, Nagri Farm, Happy Valley, Mim, Singall and Margaret's Hope in Darjeeling.

Correspondence.— 209 letters and memoranda were issued.

Publications.— Planning of Experiments—Parts I and II
'Two and A Bud' Vol. V. Nos. 3 & 4.

ASSAM ADVISORY BRANCH—ASSAM VALLEY (SOUTH BANK)

P. M. GLOVER—Senior Advisory Officer, Assam.

P. C. SHARMA—Assistant Advisory Officer.

STAFF

The Senior Advisory Officer, Assam was on local leave 16th-28th October, 1958, and the Assistant Advisory Officer was on annual leave in India from 2nd to 22nd June, 1958.

TOURING

The following garden visits were made by the Senior Advisory Officer and Assistant Advisory Officer in the Assam Valley:

Jorhat Circle	32	Visits	*Moran Circle*	9	Visits.
Golaghat Circle	20	,,	*Tingri Circle*	10	,,
Sonari Circle	16	,,	*Dibrugarh Circle*	10	,,
Nazira Circle	10	,,	*Panitola Circle*	16	,,
Nahorkatia Circle	3	,,	*Doom Dooma Circle*	17	,,

Several visits were of more than one day's duration, and a number of gardens were visited on more than one occasion. Included in the above total of 143 are 40 visits to gardens not members of the Indian Tea Association, Calcutta.

The Senior Advisory Officer, Assam toured Cachar 10th-18th June and again 11th-14th October. Visits were paid to Kallinecherra T. E. at the special request of Messrs. Octavius Steel, and to Kyang Tea Seed Bari at the special request of Messrs. Shaw Wallace. Visits were also paid to Branch H. Q. and Silcoorie T. E.

The Assistant Advisory Officer toured Cachar and visited 4 non-member gardens.

The Senior Advisory Officer, Assam toured the Tezpur Circle North Bank 14th—20th November and visited four gardens with special reference to possible side effects of Aldrin and Dieldrin applied to the soil in the control of Termites.

The Assistant Advisory Officer visited 2 non-member gardens on the North Bank.

MEETINGS

The Senior Advisory Officer, Assam attended the Annual General Meeting A.B.I.T.A. held at the Thakurbari Club on 15th November, 1958.

LECTURE AND DEMONSTRATIONS

Lectures on the "Fertiliser position 1959" were given in the Panitola and Tingri Clubs. Informal discussions were *held in District Clubs while on tour.*

A talk on "Tipping and Plucking" was given to Managers and Assistants of the Eastern Assam Company on 17th March at the request of the Superintendent.

The Senior Advisory Officer delivered an address on "Developments in Power Spraying" on Tuesday 11th November at the Fifteenth Annual General Conference held at Tocklai and gave demonstrations of power spraying to those attending the Conference, at Borbhetta.

The Senior Advisory Officer and Assistant Advisory Officer attended a demonstration of the new Ferguson F.35 Tractor given at the Race Week Exhibition Jorhat on 7th February.

A Tocklai Stall was again organised by the Advisory Branch at the Jorhat Club Race Week Exhibition illustrating the work of the Scientific Department for the benefit of the Tea Industry. The Stall proved very popular in spite of most unfavourable weather conditions, and attracted a large number of visitors.

COURSES

Three Lecture Courses each of five days' duration were held at Tocklai in February-March, conducted by the Advisory Branch, with the assistance of the Tea Taster and the Selection Officer. A demonstration of the Tocklai Withering Tunnel was given on each Course by the Resident Engineer.

Mornings were devoted to lectures and afternoons to outdoor demonstrations. A total of 85 attended, of whom 5 were from non-member concerns and 8 were trainees from Borbhetta.

The Senior Advisory Officer gave a lecture on each of the Vegetative Propagation Courses conducted by the Senior Agriculturist, on the subject of "Commercial application of Vegetative Propagation."

ADVISORY CORRESPONDENCE

816 letters and memoranda of an advisory nature were written during the year, of which 109 were to gardens non-members of the Indian Tea Association, Calcutta.

PUBLICATIONS

The following Tea Encyclopaedia Serials were published or revised during the year:

"Manuring of Young Tea" T.E. Serial 9/2 was revised in conjunction with the Senior Agriculturist.

"Handling of Plant Protection Products and Hazard to Operators" a new T.E. Serial No. 121 was written by the Senior Advisory Officer, Assam.

"Organisation of Spraying" T. E. Serial 93/2 was revised.

The following articles were published written by the Senior Advisory Officer, Assam.

"The Scope for Mechanisation in Tea Production in North East India" Tea & Rubber Mail, May 22nd 1958.

"Power Spraying of Tea" Two and a Bud Vol. 5 No. 4 December 1958.

"Research in Tea-Loss in yield due to Pests an important Problem" Statesman, December 30th 1958.

TECHNICAL REPORTS

Incidence of Pests:

Red Spider (*Oligonychus coffeae*).— A feature of this year has been a marked tendency for Red Spider to persist in many districts throughout the monsoon, more particularly on young tea and in nurseries.

Looper caterpillar (*Biston suppressaria*).— Looper caterpillar attack was serious in several gardens in the Jorhat and Golaghat Circles this year.

Black Aphid (*Toxoptera aurentii*).— This black Aphid was observed in large numbers on young shoots coming away from pruning over a wide area in February.

Flush Worm (*Laspeyresia leucostoma*).— Flush worm was prevalent particularly in the Nazira and Moran Circles where it caused considerable damage.

Hail damage:

Severe hail damage occurred on several gardens in the Doom Dooma Circle in April, and the Senior Advisory Officer paid a special visit to the worst affected areas to advise as to remedial treatment.

Aerosol Sprayers:

Field trials with the "Fontan" Aerosol Power Sprayer made by Messrs. Swingfire, Agents in India Messrs. Jardine

Hendersons, against Looper caterpillar at Doyang T.E. were carried out under commercial conditions.

Endrex was used at the rate of one pint in 10 gallons and resulted in complete control of Looper at as low a dosage rate as 6.3 gallons per acre. The acreage covered per machine per hour was 0.6; this machine is therefore about six times as efficient as a Knapsack Sprayer.

Trials with the Micronette made by Messrs. Micron Sprayers, Agents in India Messrs. Shaw Wallace, were abandoned due to mechanical trouble; while in operation, control was obtained at 5.1 gallons per acre at 0.3 acres per machine per hour.

The "Motoblo" Messrs. Kent Engineering and Foundry, Agents in India Messrs. James Finlay, arrived too late for inclusion in these trials. Preliminary small scale trials suggest it also as an efficient Aerosol Power Sprayer.

Control of Termites (*Microcerotermes sp.*) attacking living tea in the Tezpur Circle by means of application of Aldrin/Dieldrin:

Suggestions have been made that Aldrin/Dieldrin application to tea has had undesirable effects. These have fallen into the following categories:

A. *Direct effects* :

1. Actual death of tea bushes in treated sections.
2. Stunting of growth and production of an increase in banjhi growth.

B. *Indirect side effects*:

1. Increase in Looper and Red Slug caterpillar attack.
2. Increased Green fly attack followed by severe Rim Blight.

In view of the above, a questionnaire was sent out by the Advisory Officer, North Bank to gardens which had applied Aldrin/Dieldrin to tea.

The Senior Advisory Officer, Assam who was over in the Tezpur Circle for the Annual General Meeting, Assam Branch Indian Tea Association paid a visit to four selected gardens in this connection, and the following notes have been prepared as result.

Gardens visited	:	*Ghoirallie* *Sonajuli*	Empire of India & Ceylon Tea Company.
		Tarajulie	— Imperial Tea Company.
		Nahorani	— Messrs. James Finlay.

Damage done by Termites.— The damage done by *Microcerotermes sp.* to living tea is extremely serious and where this species of Termite abounds (Tezpur and Cachar) tea is virtually being eaten alive by it. Its depredations appear to be on the increase and unless effective action is taken against it, affected sections of tea will progressively drop in yield and gradually die out.

Efficacy of Aldrin/Dieldrin against *Microcerotermes sp.*— It appears that Aldrin/Dieldrin correctly applied as described in T.E. Serial 77/1 under J.3 is extremely efficacious in eradication of Termites, whether sprayed or watered onto the soil. How persistent the effect will be can only be determined by practical experience. Termites appear to be eradicated for at least two and probably three years. Indications from Cachar are that the effect may be persistent for as much as four years or more.

It is apparent that application of these insecticides mixed with fertiliser is less efficient than application as described in T.E. Serial 77/1. This is probably because:—

(*a*) Where an insecticide is mixed with a fertiliser it must be applied at that time which fertiliser application dictates, which is not necessarily the time most efficacious from the point of view of the insecticide.

(*b*) It must be applied in the manner dictated by the fertiliser, in this case away from the collar, where at least some of the insecticide is required.

No other insecticide so far has been found to be efficacious against *Microcerotermes sp.*

Aldrin/Dieldrin and death of tea bushes.— No evidence whatsoever was found that Aldrin/Dieldrin application had caused the death of tea bushes. Where mortalities had occurred in young tea, these were attributable to drought, Looper or Red Slug attack or any combination of the three. Mortalities in mature tea, as would be expected, were much more prevalent in the *older* sections, and were attributable to old age, Termite attack in the past, Branch canker (*Poria hypobrunnea*) Looper and Red Slug attack and drought in various combinations. Stripping of leaf in a cyclonic storm was reported on certain gardens in 1957 in the Circle, which had an adverse effect on bushes.

Aldrin/Dieldrin stunting of growth and banjhiness.— It is possible that the application of chlorinated hydrocarbons to tea bushes (especially when they have begun to come away again following top or medium prune) *might* have an adverse effect on growth to include stunting and banjhiness; there was no evidence of this *at the time of this visit*, even where chlorinated hydrocarbons had been applied twice in the same season or at double the recommended rates in one application. Thus even if a detrimental effect had occurred following application it would appear to be temporary only, and to be infinitely preferable therefore to the progressive eradication of the tea by *Microcerotermes sp.*

Indirect side effects.— The following potential side effects have been investigated: —

(*a*) *Looper and Red Slug.*—No evidence could be found that Aldrin/Dieldrin had caused any increase in Looper or Red Slug attack. 1957 and specially 1958 have been bad years for Looper in any event on both North and South Banks, and Looper has been equally prevalent in gardens or sections of gardens where no chlorinated hydrocarbons have been applied.

(*b*) *Green fly.*—There was a certain amount of evidence that Aldrin/Dieldrin application *may* be followed by increased

Green Fly attack with subsequent Rim Blight, though the evidence is not conclusive. In one instance where Dieldrex was actually sprayed onto the foliage of tea bushes to control Red Slug attack, a severe attack of Green Fly followed. Application in this manner is not however recommended in the control of Termites. Even were this to be the case, it would appear that such a side effect is a justifiable risk, and the necessary measures to control Green Fly should be held in readiness against its appearance.

Aldrin/ Dieldrin application in Cachar.— Aldrin/Dieldrin have been used widely in Cachar for several years in the control of Termites, no adverse effects have been proven.

Recommendations.— 1. *Control measures using Aldrin and Dieldrin against Termites should be continued.*—There is no case for abandoning them, and to do so will do infinitely more harm than good.

2. The application rate should be that recommended in T.E. Serial 77/1 under J. 3 *i.e.* 2 lbs. active principle per acre.

3. Application should be done as soon after pruning as convenient, immediately following defoliation, where this is done, would be a suitable time. It should not be delayed until regrowth after pruning commences.

4. Aldrin/Dieldrin should not be sprayed or poured or splashed onto the frame of the bushes or applied such that a heavy concentration occurs round the collar. These insecticides should be sprayed or watered onto the soil around the collars of the bushes evenly as recommended in T. E. Serial 77/1.

5. Where Aldrin/Dieldrin is applied, especially to sections which have been medium pruned, such tea being very susceptible to Green Fly attack, a careful watch should be maintained and control measures as described in T. E. Serial 109 under 1.4 para 5 (*a*) and (*e*) should be initiated immediately should Green Fly appear.

EXPERIMENTS

Short term field trials Carried out by the Advisory Branch in the Assam Valley : South Bank

1. **Eelworm** (*Heterodera marioni*):—

A field trial was laid out at Behubor T.E. to examine the effect of a soil steriliser YX 564/57 supplied by Messrs. Plant Protection Ltd., Imperial Chemical Industries, on Eelworm in a tea seed nursery.

Treatments were:

2 pints YX 564/57 in 20 gallons water per 100 sq. ft., watered on with a further 30 gallons water per 100 sq.ft.

Control—50 gallons water per 100 sq. ft.

This trial was carried out in conjunction with Mr. Austin of Messrs. Plant Protection.

An initial eelworm count was made on samples taken on 8th December, 1957, prior to any treatment being applied on 9th and 10th December. Treatment was followed in each instance by heavy rain. A period of 3 weeks was allowed between treatment and sowing of tea seed. Prior to sowing on 2nd January 1958 the beds received one round of light forking. The fact that no phytotoxic effect as result of treatment was observed at Behubor may probably be attributed to this forking. Beds at Borbhetta were not forked prior to seed sowing and there was a marked phytotoxic effect.

The overall effect on eelworm population per plot is recorded in Table 1.

Table 1: Mean eelworm population per plot.

Date	Control	Treated	Least significant difference at 5 %
8 December 1957 prior to treatment	18.0	14.8	NOT significant
29.4.58	6.2	3.3	2.6
2.6.58	11.3	5.9	3.3
22.8.58	11.3	8.5	NOT significant.

Initial eelworm population varied widely from plot to plot: the average initial population per plot between treated and control did not differ significantly. In both samples taken

in April and June, the mean eelworm population per plot was significantly less in the treated than in the control plots. The reduction in eelworm population adjusted against initial population was not however significant, being masked by the high variability of the untreated plot in the third repeat.

By August there was no significant difference between the mean population in control and treated plots. This is not considered to be of any great importance as by this time seedlings are relatively non susceptible to eelworm damage.

In March 1958 it was noted that YX 564/57 had had a marked pre-emergence weed killer effect on both monocotyledonous (thatch) and dicotyledonous, weeds. A sample assessment was made on 11th April and results are shown in Table 2.

Table 2: Numbers of weeds per 5 quadrates per plot.

Plot	Thatch		Dicotyledonous Weeds		GRASS Sps. other than Thatch	
	Treated	Control	Treated	Control	Treated	Control
I	3	4	19	60	34	37
II	0	6	9	132	40	43
III	0	12	4	36	11	71
IV	0	11	9	62	219	32
V	0	19	17	70	44	137
VI	0	10	32	81	150	10
VII	0	16	5	62	161	150
VIII	0	6	24	115	5	87
IX	1	6	19	138	128	94
X	2	28	16	78	17	60
Mean	0.6	11.8	15.4	83.4	80.9	81.1
Least significant difference at 5%	5.3		22.8		Not significant.	

The reduction in thatch and dicotyledonous weeds was significant. There was no effect on miscellaneous light grasses. These are in any event not serious weed competitors. Although no further physical counts were made, this herbicidal effect continued throughout the monsoon.

In May, 1958 the mean height, mean weight and the mean root length per plant was significantly greater in the treated than in the control plots. At the same time the Infestation Index was calculated for each plot from the formula:—

$$\frac{(\text{Grade} \times \text{Nos. plants in grade}) \times 100}{\text{No. of plants examined} \times \text{maximum grade} \times 1}$$

The eelworm infestation in the treated plots was significantly less than in the control.

In August 1958 there was no significant difference in mean height and root length per plant in treated over control plots. The latter may well be due to the difficulty in lifting the finer tap roots from the treated plots without breaking them, at that time.

In this sampling also the difference in Infestation Index between treated and control plots was not significant.

The difference in weight between plants in treated and control plots was highly significant in favour of the treated plots and the standard of plant in these beds was markedly superior to those in the untreated beds. Suppression of thatch and dicotyledonous weeds was still very marked.

In any event the final answer to such an experiment must be the number and vigour of plants obtained from the treated and control plots. A summary of plants per plot out of a "possible" of 57, the number of liftable plants based on a minimum height from the collar of 20 cms, average weight and average height per plant is given in Table 3.

Table 3 : Eelworm Trial Behubor T.E.

Plot	No Plants per plot		Liftable Plants per Plot		Average Wt in Grms		Average Ht in cms		Average Ht Liftable Plants in cms.	
	Treated	Control	Treated	Control	Treated	Control	Treated	Control	Treated	Control
I	41	43	39	35	12.2	8.1	36	30	36	33
II	54	34	44	19	9.3	5.9	31	22	35	28
III	43	45	40	37	10.5	10.0	36	32	37	35
IV	47	30	43	14	12.8	3.3	36	20	38	26
V	54	48	50	47	15.7	14.6	41	39	42	40
VI	38	13	29	4	10.5	3.8	31	18	36	25
VII	50	48	47	44	11 0	8.3	32	28	35	30
VIII	43	33	37	12	8.1	3.0	30	18	32	24
IX	49	44	47	31	13.3	6.8	37	26	38	27
X	51	27	50	7	12.8	1.9	38	17	38	22
Mean	47	36	43	25	11.6	6.6	34.8	25.0	36.7	29.0
Least Significant difference at 5%	7.3		9.9		2.4		4.2		3.4	

It will be seen that both the total number of plants and number of liftable plants is significantly greater in the treated than in the control. The average weight is significantly greater and the average height of plants as a whole and also of liftable plants is greater in the treated than in the control plots.

At Behubor T. E. application of YX 564/57 has had a highly beneficial effect.

2. **Disease of Tea Flowers attributed to** *Botrytis sp.* (*Sclerotiniaceae*):

Field trials were laid out using "Fernide" (T.M.T.D.) on six commercial Seed Baries in Upper Assam in co-operation with Mr. Austin, Messrs. Plant Protection Ltd.

(*a*) *Dhelakhat T.E.* :

There were two treatments and check, applied at high volume by means of a Universal Major Sprayer towed by means of a Fordson Major Tractor. Five rounds were applied during the flowering period at approximately 2 weeks intervals.

"Fernide" + Teepol 4.5 lbs. TMTD in 75—100 gallons of water per acre.

Water at 75—100 gallons per acre.

Check.

(*b*) *Khorijan* / *Tingamira* } *Tea Seed Companies* :

One treatment and check applied at low volume using an Aerosol power sprayer. Four rounds at Khorijan and five rounds at Tingamira during the flowering period at approximately 2 weeks intervals.

"Fernide" at 3.0—3.8 lbs. TMTD in 19.5—23 gallons of water per acre.

Check.

(*c*) *Sealkotee* / *Deohall* / *Thowra* } *Tea Estates* :

Two treatments applied at low volume using an Aerosol power sprayer. Four rounds at Sealkotee and Thowra, five rounds at Deohall during the flowering period at approximately 2 weeks intervals.

"Fernide" + Teepol 2—5 lbs. TMTD in 12—30 gallons of water per acre, according to the size of the trees.

Water + Teepol at 12—30 gallons per acre.

The data has been examined for

1. Seed weight per plot.
2. Percentage of good seed.
3. Number of seeds per lb.

for each treatment, Fernide-Water and/or Control (No spray) in each of the six Tea Seed Baries included in the trials. In Table 4 the mean weight of seed per plot is given in lbs. in Table 5 the percentage of sinkers and in Table 6 the average number of seeds in one pound.

Table 4 : Mean weight of seed per plot in lbs.

Seed Barie	No. of trees per plot	Fernide	Water	No spray	Least significant difference at 5%
Dhelakhat	29	17.8	16.5	18.2	1.55
Khorijan	10	7.7	x	7.5	2.39
Tingamira	10	24.6	x	29.6	11.41
Sealkotee	11	9.9	11.1	x	3.37
Deohall	15	36.6	32.6	x	4.91
Thowra	10	19.3	18.7	x	4.71

Table 5 : Percentage of sinkers

Seed Barie	Fernide	Water	No spray	Least significant difference at 5%
Dhelakhat	84.31	82.89	82.93	1.12
Khorijan	67.51	x	68.20	1.72
Tingamira	73.51	x	72.66	1.55
Sealkotee	52.79	57.56	x	1.58
Deohall	81.26	81·57	x	1.35
Thowra	70.67	71.08	x	1.50

Table 6 : Average numbers of seeds in 1 lb. as ascertained by daily sampling.

Seed Barie	Fernide	Water	No spray	Least significant difference at 5%
Dhelakhat	231	234	237	NOT Significant
Khorijan	187	x	180	4.5
Tingamira	186	x	184	NOT significant
Sealkotee	200	200	x	NOT significant
Deohall	201	218	x	11.5
Thowra	214	211	x	NOT significant

At Dhelakhat spray was at high volume, and high pressure, and the seed bearers of a "Manipuri" kind. Precision was relatively higher than in the other experiments being based on

a large number of degrees of freedom for error and a larger number of trees per plot. The yield from plots sprayed with water was significantly less than from no spray. Between water and Fernide the difference was not significant. On the other hand the percentage of sinkers at Dhelakhat was significantly higher in the Fernide treated plots than in the water treated and no spray plots.

There was no significant difference in the numbers of seed per lb. which varied from 231 to 237, *i.e.* 18480 to 18960 per maund.

At Khorijan and Tingamira there was no significant difference between yields from Fernide treated plots and no spray; the difference in overall yield level between the two baries is in tree size, those at Khorijan being small/medium and those at Tingamira being medium/large. Both are light leaf Assam kinds. There was no significant difference between percentage of sinkers in Fernide and no spray plots.

The numbers of seed per lb. varied between 180-187 (*i.e.* 14,400 to 14,960 per maund). At Khorijan only, the number of seed per lb. was significantly higher in the Fernide sprayed plots.

At Sealkotee, Deohall and Thowra all light leaf Assam kinds there was no significant difference in yield between Fernide and water sprayed plots, though at Deohall the yield from Fernide was 4 lbs. per plot higher than from water. Seed collection at Deohall was *difficult* due to the size and close spacing of the trees which may explain this anomaly. The overall yield level difference is explained in that at Deohall the trees were large, those at Thowra medium and those at Seaikotee small.

At both Deohall and Thowra there was no difference in the percentage of sinkers in the Fernide and water sprayed plots; while at Sealkotee the percentage sinkers in the water sprayed plots was significantly greater than in the Fernide sprayed.

The number of seed per lb. varied from 200 to 218 (*i.e.* 16,000—17,440 per maund). At Deohall only the numbers of seed per lb. was significantly greater in the water sprayed plots.

Conclusion.— In no instance has Fernide spraying resulted in any significant increase in yield over water alone or no spray. At Dhelakhat the percentage of sinkers was significantly higher in the Fernide sprayed plots than in those sprayed with water or unsprayed. At Sealkotee on the other hand the percentage of sinkers was significantly greater in the water sprayed than in the Fernide sprayed. Elsewhere differences were not significant. Treatments had a significant effect on the numbers of seed per lb. *only* at Khorijan where Fernide spray resulted in an increase of 7 seeds per lb. as compared with no spray, and at Deohall where Fernide reduced the number of seed per lb. by 17 as compared with water No importance is attached to these conflicting results.

NB.—The numbers of seed per maund recorded must NOT be taken to indicate that this is the number which will occur in the commercial seed which any of these seed baries produces. These figures are for comparative purposes only and were taken on seed *prior to sorting and grading.*

An independent trial was conducted at Tyroon T.E. by the Manager with the co-operation of the Mycological and Advisory Branches. There were four treatments:

1. $\frac{3}{4}$ lbs. Fernide + $\frac{3}{4}$ ozs. Teepol in 30 gallons of water.
2. $\frac{3}{4}$ ozs. Teepol in 30 gallons water.
3. Water alone.
4. Check.

Analysis of variance revealed no significant difference between treatments in respect of seed yield.

3. Control of Broad leaved weeds in thatch baries:

This field trial was laid out in a good thatch barie at Cinnamara T.E. There were two treatments using "Fernesta"

(a 24D product) supplied by Messrs. Plant Protection Ltd., Imperial Chemical Industries, applied by means of spray booms using a Four Oaks Tractor Mounted sprayer on 7th April.

Treatments were:

Fernesta at the rate of 1 pint in 24 gallons water per acre.
Fernesta at the rate of 2 pints in 24 gallons water per acre.
Water at 24 gallons per acre.

Thatch was cut at the end of December and the yield per plot was recorded as commercial 9″ bundles. There was no significant difference in yield in bundles from either of the treatments or control. An eye estimate of weediness was made by two separate observers.

The commonest weed was *Melastoma* sp. The least weedy plots were those sprayed with 2 pints Fernesta per acre, and the most weedy the control, with Fernesta at 1 pint per acre intermediate. Weed growth however was not so heavy in any of the plots as to cause any material effect on thatch yield.

It is considered that spraying with Fernesta at 2 pints per acre in a thatch barie in which the weed growth is very heavy would be an economic proposition.

Manuring of Medium Pruned tea:

Treatments were applied to *old* tea recovering from medium prune at Cinnamara T.E. as follows:

80 lbs. N as NPK Young Tea 1-2-2 mixture.

80 lbs. N as NPK Seed Bari 3-1-2 mixture.

80 lbs. N. as Sulphate of ammonia.

In the year of medium prune there was no significant difference in yield from any treatment, in this old tea. This year all plots were treated alike with 80 lbs. N as sulphate of ammonia. Again there was no significant difference in yield between plots manured with any of the three treatments in the year of medium prune, in the year following when all were manured alike.

Field Experiments in Gardens

The following experiments have been continued from previous years. They are now the partial responsibility of the Agricultural Branch, and results are reported in the Appendix which follows:—

N.P.K. Manuring Experiments:

Panitola T.E. Mature Tea 1954
Panitola T.E. Young Tea 1955
Murmuria T.E. Young Tea 1956
Margherita T.E. Young Tea 1958
Khoomtaie T.E. Young Tea 1958

Organic versus Inorganic fertiliser:

Jamirah T.E. 1948.

Shade × Nitrogen × Plucking:

Hunwal T.E. 1949.

The following new experiments were laid out:

Comparison of three different sources of nitrogen:

Murmuria T.E. 1958 2 Experiments.

APPENDIX

EXPERIMENTS IN THE ASSAM VALLEY, SOUTH BANK

N.P.K. Manuring Experiments:

Panitola T.E.—Mature Tea (A. 6)— This experiment was started in 1954. The tea is Gillapukri planted 4′ × 4′ square in March, 1947. Each plot has one *Albizzia chinensis* and one *Albizzia procera* shade tree.

The experiment consists of two parts. In the first part there are three levels 0 lb., 40 lbs., and 80 lbs. of each nitrogen, phosphate, and potash, and their combinations. In the second part there is a constant level of 80 lbs. nitrogen with 0 lb., 20 lbs., 40 lbs., and 80 lbs. of each phosphate and potash.

The effect of nitrogen is highly significant. Both 40 lbs. and 80 lbs. have given significantly higher yield than no nitrogen—the increase over no nitrogen being 23.70% and 44.94% respectively. 80 lbs. of nitrogen has also given significantly higher yield than 40 lbs. nitrogen. This year 80 lbs. of phosphate has given significantly higher yield than 0 lb. and 40 lbs. phosphate.

NP and NK interactions are also significant. $N_{80}P_{40}$ and $N_{80}P_{80}$ have produced higher yield than 80 lbs. nitrogen without phosphate. In so far as PK interaction $P_{80}K_{80}$ has given the highest yield.

At the level of 80 lbs. nitrogen $N_{80}P_{80}$ K_{40} gave the highest yield, but was not significant over $N_{80}P_{40}K_{0}$ or $N_{80}P_{0}K_{40}$.

Panitola T.E.—Young Tea (A. 10).— This multi-level N.P.K. experiment on young tea was started in 1955. The tea is Gillapukri and was planted 4 ft. × 4 ft. square in 1954. Each plot has one *Albizzia procera* shade tree in the centre.

This experiment consists of two parts. In the first part there are three levels—0 lb., 40 lbs., and 80 lbs. of each nitrogen, phosphate and potash and their combinations. In the second part there is a constant level of 80 lbs. nitrogen with 0 lb., 20 lbs., 40 lbs. and 80 lbs. each of phosphate and potash. Altogether there are 34 treatments with two repeats.

(*a*) *Pruning Weight*.—In 1955, the first year of the experiment, the effect of treatments was based only on weight of prunings. Only the main effect of potash was found to give significant results. Both 40 lbs. and 80 lbs. potash produced significantly greater total pruning weights than 0 lb. potash. There was no difference between 40 lbs. and 80 lbs. potash. In 1956, again both 40 lbs. and 80 lbs. potash produced a significantly greater total weight of prunings than 0 lb. potash; there was however, no significant difference between them. In the second part, with a constant level of 80 lbs. nitrogen the effect of potash only was significant. 20 lbs., 40 lbs. and 80 lbs. potash produced greater pruning weights than 0 lb. potash. 80 lbs. potash had a tendency to produce higher yield than 40 lbs. and 20 lbs. In 1957, results similar to those of 1956 were obtained. All the levels of potash gave significantly higher yields than no potash. 80 lbs. potash, again, gave higher pruning weights than 40 lbs. potash and 20 lbs. potash. In 1958 the NK interaction showed significant results and 80 lbs. nitrogen in absence of potash ($N_{80}K_0$) gave significantly lower pruning weights than $N_{40}K_0$ and N_0K_0. But 80 lbs. nitrogen combined with 80 lbs. potash ($N_{80}K_{80}$) produced the highest pruning weight and was significant over 80 lbs. potash in the absence of nitrogen (N_0K_{80}).

(*b*) *Crop Yield*.—No crop yield records were taken in 1955 but in 1956, 1957 and 1958 similar results were obtained as in case of pruning weights. The main effect of nitrogen and phosphate failed to show any significant effect but the main effect of potash was highly significant. In Table 1 below the yield of different levels of potash as shown in the second part of the analysis is given. Yield figures are in maunds of made tea per acre.

Table 1
Maunds made Tea per acre

Treatment	1956	1957	1958
0 lb. K	2.78	1.73	3.71
20 lbs. K	4.17	2.98	5.87
40 lbs. K	4.23	3.00	6.07
80 lbs. K	5.27	3.91	7.16
Critical difference at 5%	1.14	0.89	1.72

It will be seen that 20 lbs., 40 lbs. and 80 lbs. have given significantly higher yield than 0 lb. potash. In 1957, 80 lbs. potash gave significantly higher yield than 20 lbs. and 40 lbs There was no significant difference between them in 1956 and 1958 but in these two years 80 lbs potash tended to give higher yield. The effect of the NK interaction was significant in 1957 and 1958 in the first part of the analysis. In both these years 80 lbs. potash in presence of 80 lbs. nitrogen gave the highest yield and gave significantly higher yield than 80 lbs. potash and no nitrogen.

(c) *Summary of important obsevations.*—It appears from the above that potash is highly beneficial to this young tea and increases both leaf yield and pruning weight. Even a small level of 20 lbs. potash has shown significantly beneficial effect. 80 lbs. potash has, however, given the best result. As regards the overall effect of nitrogen and phosphate, no significant differences were obtained during these four years. It has, however, been seen that a combination of 80 lbs. of nitrogen with 80 lbs. of potash has tended to give more crop yield and pruning weight of tea than that of 80 lbs. of potash without nitrogen.

Murmuria T.E. (A. 11).— This experiment was started in 1956 on young Doom Dooma Assam tea planted at 5 ft. × 2 ft. in 1954. Shade trees are *Albizzia chinensis* and *Albizzia odora-*

tissima spaced at 20 ft. x 20 ft. There are three levels of nitrogen—80 lbs., 120 lbs., and 160 lbs. in all combinations with 0 lb., 20 lbs. and 40 lbs. of each of phosphate and potash. Altogether there are 27 treatments with 3 repeats.

There was no significant difference between any of the treatments in 1958. But as observed in 1957, trends suggest that nitrogen alone in excess of 120 lbs. per acre may have a depressing effect. There are also indications that at a level of 80 lbs. nitrogen per acre both phosphate and potash at 20 lbs. per acre can be beneficial.

Margherita T.E. (A. 21).— Treatments as for A 11 were applied for the first time in 1958. The tea is Raidang/Samdang planted in April, 1952 at a spacing of 5′ × 2′. Shade trees are *Albizzia odoratissima* and *Albizzia procera* spaced at 35′ × 36′. There was no significant difference between 80 lbs., 120 lbs. and 160 lbs. nitrogen per acre. The various combinations of the above three levels of nitrogen with 20 lbs. and 40 lbs. of each phosphate and potash also failed to produce any significant difference. Lack of response to nitrogen may possibly be due to application of doses higher than 80 lbs. nitrogen per acre.

Khoomtaie T.E. (A. 22).— Treatments were applied for the first time in 1958. The tea is Betjan planted 5′ x 2′ in February/March 1952. There are three levels of nitrogen—80 lbs., 120 lbs. and 160 lbs. with at each 0 lb., 20 lbs. and 40 lbs. of each phosphate and potash. Altogether there are 27 treatments with 3 repeats. Effect of phosphate only is highly significant 40 lbs. of phosphate has produced significantly higher yield than 20 lbs. and 0 lb. of phosphate. There was no significant difference between the two latter treatments. Effect of potash and nitrogen is not significant. Nitrogen was applied at three levels of 80 lbs., 120 lbs. and 160 lbs. per acre. The various combinations of the above three levels of nitrogen with 0 lb., 20 lbs. and 40 lbs. each of phosphate and potash also failed to show any difference in yield. The lack of response due to nitrogen manuring is possibly due to application of doses higher than 80 lbs. per acre.

Jamirah T.E. (A 2).— The experiment is now in its eleventh year. The tea is Bokel Manipuri planted in 1913-14 at 4′ × 4′ square. The soil is sandy. Tea is heavily shaded with *Dalbergia assamica, Albizzia procera* and *Albizzia lebbek.*

Table 2

Treatments.	Yield in mds. of made tea per acre.
1. 80 lbs. Nitrogen as sulphate of ammonia	= 30.33
2. 80 lbs. nitrogen as oilcake	= 29.16
3. Check (No manure)	= 23.25

Difference required for significance at 1% level = 4.94 mds. per acre.

It will be seen that as in previous years highly significant results have been obtained. Both organic and inorganic fertilisers have given yields significantly greater than no manure. There is, however, no difference between the yields of the two fertilisers on this light sandy soil. The percentage gains in yield over Check by sulphate of ammonia and oilcake are 30.45% and 25.42% respectively.

Shade Nitrogen and Plucking:

Hunwal T.E.— The treatments were

Two levels of tipping 6″ and 9″

Two levels of N, 40 and 120 with at each 40 lbs. phosphate and potash.

Shade and No shade

In 1956-57 the whole area was medium pruned and all plots were plucked and manured alike. There was in 1957 no significant difference in yield between plots previously manured with the higher or lower level of N, nor between those harder or lighter plucked. The whole area was again manured and plucked alike in 1958, and again only shade has shown any

significant effect. This experiment has achieved its object and is being terminated and a write up is in preparation.

Comparison of three different sources of nitrogen:

Two new experiments were laid out during the monsoon at Murmuria T.E. one on a very light and one on a much heavier soil, whose object it is to compare three different sources of nitrogen applied to tea.

Sources of nitrogen are:

Ammonium sulphate
Ammonium chloride
Urea.

There are four levels of nitrogen 0-80-120-160 lbs. N per acre and three repeats.

Preliminary yields were collected as from August 1958 and treatments will be applied for the first time in 1959.

ASSAM ADVISORY BRANCH—ASSAM VALLEY: NORTH BANK

D. J. GRAY—Advisory Officer.

STAFF

The Advisory Officer proceeded on local leave and special leave in the U.K. from October 10th to November 20th.

Shri Raghubir Singh joined the Branch as stenographer on March 10th and was confirmed in his appointment on September 10th.

Shri P. C. Borpuzari joined the Branch as Field Assistant on 21st July and resigned his appointment on 29th November. Shri L. N. Barua joined the Branch as Field Assistant on six months probation on December 15th.

TOURING

71 visits were made to gardens including 2 non-member gardens in the Mangaldai, Borsola, Tezpur, Bishnauth and North Lakhimpur Circles.

4 gardens were visited by the Senior Advisory Officer, Assam. 5 gardens were visited by the Selection Officer.

MEETINGS

Monthly Managers' Meetings for the Tezpur Circle, Zone III A.B.I.T.A. were attended from time to time in connection with the laying out of garden experiments and other matters.

LECTURES AND DEMONSTRATIONS

The Advisory Officer, assisted in the preparation of the Tocklai Exhibition stall for the Jorhat Race Week Exhibition.

The Advisory Officer took part in the General Lecture Courses held at Tocklai from February 17th to March 14th and gave lectures on planting of "Young Tea" and the "General Principles of Shade."

CORRESPONDENCE

A total of 872 letters were received during the year and 930 were despatched, about one third of these dealing with advisory matters.

PUBLICATIONS

No publications were made during the year.

TECHNICAL REPORTS

Insect Pests:

Certain insect pests were abnormally severe during the 1958 season.

Red Slug (*Heterusia magnifica*).—Red Slug occurred in epidemic form on a number of gardens early in the year.

Looper Caterpillar (*Biston suppressaria*).—Severe attacks of Looper caterpillar were experienced by many gardens in the Tezpur Circle. Large areas of tea were completely defoliated.

Tea Mosquito (*Helopeltis theivora*).— Damage, closely resembling that caused by the tea mosquito was observed on a number of gardens in the Tezpur district during May and June. Tea mosquito has not been observed in this district for many years. It was not possible to collect specimens of the insects concerned and it is therefore not known with certainty whether *Helopeltis theivora* was responsible.

Buprestid larvae (*Sternocera aurosignata*).— Shade tree nurseries and young shade trees in the field were severely attacked by *Buprestid* larvae. The larvae caused extensive damage to the roots from soil level to a depth of 18″ or more. As a result the trees died back and in many cases died completely. *Albizzia odoratissima*, and *A. procera* were the two species most commonly attacked, but *A. lebbek* and *A. moluccana* have also been damaged.

Side Effects of Aldrin and Dieldrin:

A number of reports were received from Managers in the Tezpur Circle that Aldrin and Dieldrin applied to the soil for the control of termites had produced undesirable side effects.

It was suggested that Rim blight and *Jassid* (green fly) attack had been induced and the bushes themselves had flushed poorly during the plucking season. The evidence produced was inconclusive and a number of trials have, therefore, been arranged to study the effect of different times of application of these insecticides on the incidence of pests and the health of the tea bushes. Treatments will be applied in the first four months of 1959.

Black Alkathene in Nurseries and Young Tea:

Small scale trials were carried out by a garden in the Tezpur Circle to investigate the possibility of using black alkathene sheeting for weed control in nurseries and young tea. Preliminary results showed no ill effects on the growth of young nursery plants and it is, therefore, hoped to carry out more extensive trials next year.

EXPERIMENTS

The following experiments have been continued from previous years.

N. P. K. Experiment:

Borjuli T.E. (1954)

Inorganic versus Organic Nitrogen Experiment:

Halem T.E (1933)

These experiments are now the partial responsibility of the Agricultural Branch, and results are reported in the appendix which follows.

The following new experiments are being started.

Nitrogenous Manuring Experiment.— Three different sources of inorganic nitrogen are included viz. sulphate of ammonia, urea and ammonium chloride. Each will be applied at three rates, to provide 80, 120 and 160 lbs. N. per acre. There is also a check plot which receives no manure. The ten treatments are replicated four times. The experiment is being laid out on two estates, Moinajulie T.E. and Pertabghur T. E.

Cultivation Experiment.— This experiment is designed to study the effect of different cultivation practices on the yield and crop distribution of young hedge planted tea. There are three rains treatments and three cold weather treatments. The experiment is being laid out on Halem T.E.

Stock 367 trial.— The nurseries for this trial, which includes Stock 367, Khorijan and Stock 203 were sown during the last quarter of the year at Monabarrie T.E.

STATION REPORT

Visitors :

The Director, Tocklai Experimental Station, visited the Branch in January and again in September in connection with the establishment of a permanent site for the Advisory Branch.

The Maintenance Engineer, Tocklai, visited the Branch in February and also in October in connection with the construction of the Advisory Officer's bungalow and staff quarters.

The Senior Advisory Officer, Assam, visited four gardens in the Tezpur Circle in November in connection with reported side effects of Aldrin and Dieldrin applied to the soil in the control of termites. Details are given above and also in the report of the Assam Advisory Branch.

The Selection Officer, visited five gardens on the North Bank in connection with vegetative propagation and seed bari selection schemes.

Buildings :

A permanent site for the Branch has been obtained. Two staff quarters have been completed and construction of the Advisory Officer's bungalow is in hand.

APPENDIX

AGRONOMIC EXPERIMENTS IN ASSAM VALLEY (NORTH BANK)

Inorganic Versus Organic Nitrogen Experiments :

Halem T.E.—Expt. No. A.3 :— This experiment was started in 1933 with the following treatments:—

1. Check	...	No manure.
2. Cattle Manure	...	200 Mds. per acre.
3. Inorganic fertiliser	...	40 lbs. Nitrogen per acre.
	...	20 lbs. Phosphate per acre.
	...	20 lbs. Potash per acre.

The tea is a Dark Leaf Manipuri kind planted in 1922-23 at a spacing of 8′ × 4′ triangular. Shade trees are *Albizzia chinensis* and *Albizzia procera* planted at a spacing of 20′ × 20′. Soil is very sandy.

In 1958 the cattle manure used contained 0.704% Nitrogen on wet weight. Thus an application of 200 mds. per acre amounted to 115.74 lbs. Nitrogen per acre. Yields in 1958 are as follows :—

Table 1 :

Treatments.	Yield in mds. per acre.	Nitrogen in lbs. per acre.	Cost per acre.
Check ...	20·40	NIL	NIL
Cattle manure ...	25·23	115·74	Rs. 42·66
Inorganic fertiliser	25·56	40·00	Rs. 88·96

Difference required for significance at the 5% level ... = 0.31 Mds. per acre.

Yields from both organic and inorganic fertilizers are highly significant over no manure, the former yielding 23.68% and the latter 25.56% more crop than no manure. There is, however, no significant difference between the two fertilizers. Similar results have also been obtained in the previous years. The following table shows the cost per pound of nitrogen and increase in yield per pound of nitrogen of each of the fertilizers. To obtain comparative figures for nitrogen only, the cost of

superphosphate and muriate of potash along with the proportionate cost of freight, application etc. has been deducted from the total cost of inorganic fertilizer.

Table 2:

	Cost per pound of nitrogen.	Increase in yield in mds. for each pound of nitrogen.
Cattle Manure ...	0.37 n.P.	0.042
Sulphate of Ammonia in the mixture ...	1.34 n.P.	0.12

The results of this experiment show that Cattle Manure is only about ⅓ as efficient as Sulphate of Ammonia and therefore to get an equivalent yield nearly three times the amount of nitrogen as in Sulphate of Ammonia are to be applied. Although Cattle Manure even at these high rates appears to be cheaper, it will be impossible to apply at this rate all over a garden. Also with the increase in demand, the price of Cattle Manure is likely to go up so high that the present apparent advantage of cheapness will entirely disappear.

N.P.K. Manuring Experiment:

Borjuli T.E.—Expt. No. A.8:— This multilevel N.P.K. experiment was started in 1955. The tea is a light leaf Assam (Goipani) planted 4½ ft. × 4½ ft. triangular in 1939. Shade trees are *Albizzia chinensis* and *Albizzia procera* planted between 1952 and 1954 at a spacing of 35 ft. triangular

There are two levels of nitrogen—40 lbs. and 80 lbs. per acre and three levels of 0 lb., 20 lbs. and 40 lbs. per acre of each of phosphate and potash, making 18 different treatment combinations. In addition there is one no manure treatment. Therefore, altogether there are 19 treatments.

In 1958 the overall effect of the fertilizers is significant. This is shown in the table below. The yield figures are in maunds of made tea per acre.

Table 3:

Treatments		Yield
Fertilizers	...	12.62
Check	...	9.74

Difference required for significance at 0.1% level = 1.92

The fertilizers have highly increased the yield over check. The increase is to the extent of 29.5%.

The main effect of nitrogen also is highly significant. The yield figures in maunds of made tea per acre of the two nitrogen levels are given below: —

Table 4:

Treatments	Yield
40 lbs. Nitrogen	11.94
80 lbs. Nitrogen	13.30

Difference required for significance at 0.1% level = 0.88

80 lbs. nitrogen has increased the yield over 40 lbs. nitrogen by 11.4%.

Phosphate and potash have failed to show any significant result. The effects of different interactions of nitrogen, phosphate and potash are also not significant. The responses to the different levels of phosphate and potash, however, are given below: —

Table 5:

Treatments	Maunds of made tea per acre.
0 lb. Phosphate	12.86
20 lbs. ,,	12.22
40 lbs. ,,	12.79
0 lb. Potash	12.46
20 lbs. ,,	12.74
40 lbs. ,,	12.66

ASSAM ADVISORY BRANCH—CACHAR

E. D. HEATH—Senior Advisory Officer

STAFF

Shri P. Deb Roy, Field Assistant, proceeded on transfer to the West Bengal Advisory Branch on December 17th. There were no other changes in Staff.

TOURING

The Senior Advisory Officer paid 110 advisory visits to gardens in Cachar, of which 16 were to non-members. Touring was curtailed in December owing to illness.

The Assistant Advisory Officer, Assam toured Cachar during the second quarter and visited 4 non-member gardens. The Tea Taster, Tocklai, toured Cachar during the second quarter and visited 15 gardens. The Selection Officer, Tocklai, toured Cachar during the second quarter and visited 10 gardens. The Senior Advisory Officer, Assam visited one garden during the second quarter, and two gardens during the fourth quarter, by special request.

Thus a total of 142 garden visits were realised during the year.

In addition to touring, 376 tea samples were received by the branch during the year for tasting and report, largely in connection with some manufacturing fault, or a change in manufacturing procedure.

MEETINGS

The Senior Advisory Officer, together with the Director, attended the Annual General Meeting of the Surma Valley Branch, Indian Tea Association in February. The Senior Advisory Officer attended the Annual Conference at Tocklai in November, and presented a paper dealing with the "Manufacture of Common Teas".

LECTURES AND DEMONSTRATIONS

During the Annual Lecture Courses at Tocklai, the Senior Advisory Officer gave lectures on "Tea Nurseries", "Soil Management", "Manuring of Mature Tea", "Manuring of Shade" and "Pruning of Mature Tea". Demonstrations relating to these subjects were given at Borbhetta.

CORRESPONDENCE

During the year 804 letters were received and 896 letters dispatched, about one third dealing with advisory work and the rest with administration.

PUBLICATIONS

Cachar Quarterly, Vol. III, No. 1-4 were published during the year.

An article on "Aerosol Spraying" was included in "Two & a Bud" Vol. V, No. 2.

A statistical paper entitled "Size and Shape of Plots for Field Experiments with Tea" was submitted to the Empire Journal of Experimental Agriculture.

EXPERIMENTS

BRANCH EXPERIMENTAL WORK

Level of Nitrogen Manuring:

ABBA trial of different levels of nitrogenous manuring to dark-leafed tea under heavy shade.

When this experiment was started in 1955, treatments were:

A. 80 lb. nitrogen in March.

B. { 80. lb. nitrogen in March.
80. lb. nitrogen in July.

The net result was that the lower level of nitrogen (80 lb.) gave almost 20% more crop than the higher level (160 lb.).

Accordingly, treatments in 1957 were altered to:

A. 80 lb. nitrogen in March.

B. { 80 lb. nitrogen in March.
40 lb. nitrogen in August.

The result was again a decrease in crop at the higher level (120 lb.) of nitrogen, though this time only to the extent of about 7%.

Treatments were again altered in 1958 to:

A. 60 lb. Nitrogen in May.
B. 90 lb. Nitrogen in May.

1958 results were almost identical for both treatments, the very slight difference of 2% being still in favour of the lower level (60 lb.) of nitrogen.

Treatments in 1959 will remain as for 1958, in order to take up any residual effects from previous years. The indication seems to be that 60 lb. nitrogen as Sulphate of Ammonia is all that is required by the particular kind of tea under heavy shade.

Yields for the past 3 years are given in table below, and should be related to the different treatments for those particular years.

Table 1: Level of Nitrogen Manuring Experiment

	1956		1957		1958	
Plots	Treat. lb. N/acre	Yield mds/ acre	Treat. lb. N/acre	Yield mds/ acre	Treat. lb.N/acre	Yield mds/ acre
A	80	19.00	80	14.84	60	23.56
B	80 } +80 }	15.96	80 } +40 }	13.93	90	23.06

Pruning of Young Tea:

Two experiments are in progress at the branch designed to compare several common systems of pruning young tea in Cachar with the Tocklai standard system. The tea was planted

in 1957 and the first treatments applied during the cold weather of 1957/58. The current season was the first during which plucking was carried out. The treatments, with their respective 1st year yields are shown in table 2 and 3 below. Fgures represent mds./acre.

Table 2—Treatments and Yields in First Experiment.

Treatment	Pruning	Plucking	Yield mds/acre.
1	Tocklai Standard (18″ cut across & centered)	30″	0.58
2	Skiff at 42″	Pluck to janam	0.20
3	Unpruned	Tipped at 40″ & Pluck to janam	0.47
4	Unpruned	Unplucked	Nil
5	18″ cut across, no decentre.	30″	0.88

The second experiment contains only the treatments numbered 1, 2 and 3 in the first experiment above. Yields are given in table 3.

Table 3—Treatments and Yields in Second Experiment.

Treatment	Pruning	Plucking	Yield, mds/acre
1	Tocklai Standard (18″ cut across and centered)	30″	1.00
2	Skiff at 42″	Pluck to janam	0.79
3	Unpruned	Tipped at 40″ & pluck to janam	0.84

It is far too early in the experiment to draw any real conclusions from these results, except to say that the lower the pruning and plucking, the higher the yield in the first year, within the limits of this experiment.

Polyclonal Seed Bari :

Using 6 selected clones developed by the branch, a polyclonal seed-bari was established in June 1958.

The bari consists of 7 blocks, each of 7 plants; each block is one of the branch standard clones, of which there are 6, plus one specially selected seedling of a dark-leafed jat. The planting is 15′ triangular, in such a way that each seedling is surrounded by one plant from each of the 6 clones. The seedlings therefore become the nucleus of each polyclonal block.

Each of the 6 clones has undergone three years rooting trials, and has proved itself comparatively hardy, drought-resistant, fairly free of pests and diseases, particularly Red Spider, and very easy to propagate, the latter being most important if any block of the bari is subsequently required to be replicated on a commercial scale. The "nucleus" plant in each block was specially selected for extreme vigour, branching habit, drought resistance and pubesence. To meet these specifications nine were finally chosen from twelve hundred probables. Seven have been planted and two are in reserve against mortalities.

Layout of the bari is shown below, the six clones being denoted by A-F and the seedling by K. (One block enclosed).

```
         C B A E C B A
        D K F K D K F
       C E A B C E A
      D K F K D K F
     C B A E C B A
    D K F K D K F
   C E A B C E A
```

Leaf from the mother-bushes of all clones has been manufactured a minimum of 12 times, including CTC and orthodox manufacture.

The selected parents for the polyclonal seed bari have consistently given teas with good liquoring qualities, plus desirable individual characters.

The 'nucleus' plants however are as yet an unknown quantity, and provide a random variable within each polyclonal block. Each block, although it contains the same 6 clones, contains a different "nucleus" plant and will therefore give progeny which phenotypically may be only slightly different but genetically may be very different.

The bari is expected to produce the first small crop in November/December 1960, although this is not expected to be representative seed. A fair sample of seed may be expected in 1961/62.

The further progress of the seed bari can be decided after observation of its progeny. The progeny should at least provide material useful for further clonal selection.

Nucleus Clonal Area:

Using the same 6 clones as are represented in the polyclonal Bari, 6 nucleus clones were established in May. Each nucleus clone consists of 64 plants, planted in hedges 4′ 6″ apart. Local experience shows that mature healthy bushes at this spacing will produce around 500 usable plants per year from two propagations. Each nucleus clone therefore should produce some 32,000 usable plants per year at maturity, enough to plant out nearly 50 acres per year from the 6 clones, if desired.

FIELD EXPERIMENTS ON GARDENS

The experiments listed below were continued during the year.

N.P.K. Experiemnts:

Roopacherra T.E. (1955), Bhubandhar T.E. (1955), Pathini T.E. (1956), Chandkhira T.E. (1956), Sephinjuribheel T.E. (1956).

The last of these is run by the Scientific Officer Jokai (Assam) Co., and the second last by the Senior Advisory Officer.

entiating between the experimental area and non-experimental area only, results of which are given below:

Table 4—Number of Flushworm-affected shoots per acre at each plucking round

Date	Treated Area	Untreated Area
24-7-58	16	not counted
31-7-58	16	„ „
6-8-58	16	„ „
13-8-58	72	„ „
19-8-58	44	„ „
27-8-58	64	„ „
2-9-58	128	„ „
9-9-58	140	„ „
16-9-58	100	0·44
23-9-58	70	0·25
30-9-58	60	0·50
7-10-58	54	0·39
14-10-58	64	0·67
23-10-58	138	1·20
31-10-58	106	1·50
7-11-58	100	1·33
17-11-58	104	1·08
27-11-58	82	0·75
8-12-58	48	0·42
*TOTAL	926	8·53
*AVERAGE	84·2	0·78

*from 16-9-58 onwards only.

These figures indicate that there is some indirect means, as yet not determined, by which the application of Dieldrin to tea may bring about an increase in Flushworm incidence.

Branch Manufacturing Experiments

The co-operation of the Management and Staff of Silcoorie T.E. made it possible to carry out an extensive series of manufacturing trials during the 1958 season.

Fresh leaf was available throughout the year from Branch plots, and from Silcoorie T.E. Occasionally leaf of other jats was brought from outside gardens for comparative manufacture. Clonal leaf as well as "commercial" leaf was used.

Withering facilities included wire racks and hessian chaungs, the air over which could be controlled in regard to both speed and temperature, so that controlled withering was available throughout the season.

Rolling facilities permitted the manufacture of orthodox and "CTC type" teas. A battery of 4 miniature rollers, powered by an electric motor, unfortunately arrived too late in the season to be utilised, but will help to increase the experimentation possible in 1959.

Fermenting room space was kindly allocated in Silcoorie factory which, although not humidified, is clean and cool.

With the attachment of a miniature drying box below the bottom tray of an E.C.P. drier, and a drying tray above the top tray of a Venetian dryer, a wide range of temperatures was available for firing the experimental samples. Samples were sorted, where necessary, by hand seiving, except where the quantity of tea made was sufficient to pass over sorting machinery.

Although most of the manufacture was of an exploratory nature, with regard to the facilities available and the various means of utilising them, nevertheless much information was gained of a commercially useful nature, and will at least provide a basis for future, more detailed, investigation.

During the year 32 manufacturing trials producing a CTC type tea were conducted. These were mainly Clonal comparisons, comparisons between clones and jats, and an investigation into the potentials of some of the more commonly grown dark-leafed jats for their manufacture by the CTC process. Results indicate that leaf from dark-leafed jats can produce a useful standard of CTC tea, this occasionally being reported on as superior to samples produced from light leafed jats. Similar results have been noted from time to time at Tocklai.

Orthodox manufacture was carried out at least once a week during the greater part of the season. This included regular manufacture of leaf from the six branch standard clones. In addition, leaf from 55 selected mother bushes at Silcoorie

T.E. was manufactured on three occasions towards the end of the year.

The various experiments conducted were not repeated a sufficient number of times to justify the publication of results here, but they have indicated that teas without any trace of the plain, common characters usually associated with the Cachar marks can be produced from Cachar leaf under Cachar conditions. On this assumption, detailed plans for replicated experimentation in 1959 are being prepared.

STATION REPORT

Owing to the impending sale of Silcoorie T.E. steps were taken to complete the purchase of the bungalow and adjacent land. A total area of 26.88 acres was surveyed, demarcated and temporarily fenced off with bamboo fencing. Permanent boundary fencing will be erected as time and labour permit. As from January 1st, 1959, the branch will be entirely self-contained. The branch labour at present residing outside the branch area will be moved in as the pucca labour houses are completed. Construction of these are progressing satisfactorily.

The second 5 kw. diesel alternator was not received on time owing to delay caused by Customs at the port of entry. It is expected to be installed however during the first quarter of 1959, so that it will be ready to supply the necessary power for miniature manufacture machinery.

APPENDIX

Agronomic Experiments in Cachar

Pruning/Skiffing Experiments :

Aenakhal T.E.—Expt. No. C.8.— This experiment was started in 1955 with the following treatments:—

1. Annual Prune.
2. Alternate Prune and Light Skiff.
3. Alternate Prune and Deep Skiff.
4. Prune—Light skiff—Prune.

The tea is Manipuri hybrid, planted in 1932 at 4 ft. × 4 ft. triangular. *Albizzia chinensis* trees were stump planted in the plots in February, 1955.

The following table gives the yield in maunds of made tea per acre of the treatments from 1955 to 1958.

Table No. 1:

Treatment	1955		1956		1957		1958		TOTAL
	How Pr./Sk.	Yield from 2-8-55	How Pr./Sk.	Yield	How Pr./Sk.	Yield	How Pr./Sk.	Yield	
1	Pruned	10·60	½" up	18·20	½" up	17·08	½" up	22·55	68·43
2	Pruned	12·68	L.S.	25·91	1" up	17·27	L.S.	29·30	85·16
3	Pruned	12·76	D.S.	25·81	1" up	17·97	D.S.	30·43	86·97
4	Pruned	10·94	L.S.	22·84	1" up	16·81	½" up	24·37	74·96
Critical difference at 5% level		Not sig.		5·16		Not sig.		4·61	

N. B.—L. S.—Light skiff to original tipping height.
D. S.—Deep skiff to 4 inch below the tipping height.

In 1955 all plots received the same treatment and no significant difference was obtained.

In 1956, plots of treatments 2, 3 and 4 were skiffed and gave higher yield than treatment 1 which was pruned but only in case of treatments 2 and 3 the increase was significant. There was no significant difference between the skiffed plots. In 1957 all the plots of the different treatments were pruned and no significant result was obtained.

In 1958, significant results between treatments were obtained. Plots of treatments 2 and 3 were light and deep skiffed respectively and produced significantly higher yield than plots of treatments 1 and 4 which were pruned. There was, however, no significant difference between treatments 2 and 3 or 1 and 4.

From the results obtained so far it is seen that both light and deep skiffs have given significantly higher yields than pruning. For this reason treatment 1 (Annual Prune) has given lower yields than other treatments having either deep or light skiff in their cycles. Treatments 2 and 3 have now completed two cycles and given 24.45% and 27.09% more crop respectively than the annual prune. The difference between these two treatments is negligible but as a safeguard against red spider and drought, treatment 3 having a deep skiff year appears to be more advantageous.

Final conclusions, however, cannot be drawn till treatment 4 completes at least 2 cycles. It may also be mentioned that the effect of treatments on quality has not been assessed.

West Jalinga T.E.—Expt. No. C.4.— This experiment was started with the following treatments:—

1. Annual Prune ($\frac{1}{2}''$ up).
2. Alternate Prune and Light Skiff.
3. Alternate Prune and Deep Skiff.
4. Prune—Prune—Skiff.

The tea is Jalinga planted $4' \times 4'$ triangular in 1941. Shade trees are mixed and evenly heavy and were planted in 1944.

The following table gives the yield figures of the different treatments in maunds of made tea per acre for the years 1957 and 1958.

Table No. 2:

Treatment	1957		1958		Total
	How Pruned/Skiffed	Yield	How Pruned/skiffed	Yield	
1	Pruned at 32"	8·36	Pruned ½" up	11·64	20·00
2	Pruned at 32"	9·08	L. S.	16·16	25·24
3	Pruned at 32"	8·42	D. S.	13·05	21·47
4	Pruned at 32"	8·84	Pruned ½" up	12·71	21·55
C-D. at 5% level	Not significant			2·44	

N. B.—L. S.—Light Skiff to original tipping height.
D. S.—Deep Skiff to 4" below the tipping height.

1957 was the first year of the experiment when all the plots were pruned at 32" from the ground level. No significant difference in yield was obtained in that year. In 1958 according to the treatment cycles, plots of Treatments 2 and 3 were light and deep skiffed respectively and plots of Treatments 4 and 1 were pruned. Significant results have been obtained this year. Plots of Treatment 2 which were light skiffed gave significantly higher yield than the plots belonging to Treatments 3, 4 and 1. There was, however, no significant difference between the latter treatments.

Burnie Braes T.E.—Expt. No. C.6.— This experiment was started in 1955 with the following treatments:—

Treatment 1 ... Annual Prune (½" up).
Treatment 2 ... Alternate Prune and Light Skiff.
Treatment 3 ... Alternate Prune and Deep Skiff.
Treatment 4 ... Prune 1" up—Light Skiff—Deep Skiff.

The tea is Tingamira planted 4 ft. × 4 ft. triangular in 1949. Shade trees are *Albizzia chinensis* spaced at 24 ft. × 24 ft. triangular.

The following table gives the yield figures in maunds of made tea per acre of the treatments from 1955 to 1958.

Table No. 3:

Treat-ment.	1955		1956		1957		1958		TOTAL
	How Pr./Sk.	Yield	How Pr./Sk.	Yield	How Pr./Sk.	Yield	How Pr./Sk.	Yield	
1	Pruned at 24″	16.05	½″ up	18.01	½″ up	16.40	½″ up	17.69	68.15
2	Pruned at 24″	15.62	L.S.	23.55	1″ up	16.88	L.S.	20.83	76.88
3	Pruned at 24″	16.14	D.S.	22 68	1″ up	16.80	D.S.	19·71	75.33
4	Pruned at 24″	15.77	L.S.	23.67	D.S.	20.25	1″ up	17.54	77.43
C. D. at 5% level		Not sig.		1.44		1.44		1.32	

N.B.—L.S.—Light skiff to original tipping height.
D.S.—Skiff to 4″ below the tipping height.

In 1955 all plots received the same treatment and no significant difference was found.

In 1956 plots of Treatment Nos. 2, 3 and 4 were skiffed and all gave significantly higher yield than the pruned plots of Treatment 1 (Annual prune). There was, however, no significant difference between them.

In 1957 the plots of Treatment No. 4 were deep skiffed and gave significantly higher yield than the plots of Treatment Nos. 1, 2 and 3 which were all pruned. There was again no difference between the latter treatments.

In 1958, plots of Treatment Nos. 2 and 3 were light skiffed and deep skiffed respectively and gave significantly higher yield than the plots of Treatment Nos. 1 and 4 which were pruned. There was no significant difference between the skiffed plots.

Treatment Nos. 2 and 3 have now completed 2 cycles and have given 12.81% and 10.54% more crop respectively than the annual prune (Treatment 1) from 1955 to 1958.

It is seen from the results obtained so far that both light and deep skiffs have given significantly higher yield than pruning. For this reason the Treatment 1 (Annual Prune) has given lower yield than other treatments having either deep or light skiff in their cycles. As there is not much difference in yield between Treatments 2 and 3, it appears that the latter would be more suitable having deep skiff in its cycles. This would minimise the danger of red spider attack and drought.

However, it is too early to draw any final conclusions till Treatment No. 4 which has the longest cycle also completes at least two cycles. It may also be mentioned here that effect of treatments on quality has not been assessed.

N.P.K. Manuring Experiments:

Pathini T.E.—Expt. No. C.9.— The Pathini N.P.K. Manuring experiment was started in 1955. The tea is Manipuri and is in *bheel* soil. The analysis of the yield figures in 1958 has not shown any significant differences between the treatments. This was also observed in 1956 and 1957. Below is given the summarised results of the experiment for the last three years. The yield figures are in maunds of made tea per acre.

Table No. 4:

Treat. / Year	$N_0 P_0 K_0$	$N_{40} P_0 K_0$	$N_0 P_0 K_{40}$	$N_0 P_{40} K_{40}$	$N_0 P_{40} K_{80}$	$N_0 P_{80} K_{80}$	$N_{40} P_{80} K_{80}$
1956	16.74	16.97	19.12	18.06	16.16	16.77	17.17
1957	17.46	17.25	21.71	20.05	17.65	17.45	19.62
1958	11.81	11.35	12.83	14.57	16.10	13.14	14.22
Total	46.01	45.57	53.66	52.68	49.91	47.36	51.01

N denotes Nitrogen
P ,, Phosphate
K ,, Potash
Associated figures denote lbs. of nutrient/acre.

The treatment giving only nitrogen ($N_{40} P_0 K_0$) has recorded the lowest yield in the last three years. But it may be noted that 40 lbs. of potash alone ($N_0 P_0 K_{40}$) and the combinations of potash and phosphate in equal proportions of 40 lbs.

or 80 lbs. (N_0P_{40} K_{40}) and (N_0 $P_{80}K_{80}$) have tended to give higher yields each year than other treatment.

Bhubandar T.E.—Expt. No. C.1.— This N.P.K. Experiment was started in 1955. The jat of tea is Chumoijan and was planted in 1919 at 5 ft. × 5 ft. triangular spacing. Shade consists of young *Albizzia chinensis* trees planted at 45 ft. × 45 ft. triangular spacing.

The soil is a true *bheel* soil. In Cachar, these soils were formed under waterlogged anaerobic conditions and are characterised by their high nitrogen content and appreciably rich humified substance.

The object of the experiment is to see what effects nitrogen, phosphate and potash have on the yield of mature tea under the above conditions. The treatments are as follows:—

Treatment:— 1. N_0 P_0 K_0
2. N_{40} P_0 K_0
3. N_0 P_0 K_{40}
4. N_0 $P_{40}K_{40}$
5. N_0 $P_{40}K_{80}$
6. N_0 $P_{80}K_{80}$
7. N_{40} $P_{80}K_{80}$

N denotes Nitrogen.
P ,, Phosphate.
K ,, Potash.

Associated figures denote lbs. of nutrient per acre.

Preliminary yields were taken in 1955 and the results of 1956, 1957 and 1958 are given below. Yield figures are in maunds of made tea per acre.

Table No. 5:

Treat. / Year	N_0 P_0 K_0	N_{40} P_0 K_0	N_0 P_0 K_{40}	N_0 P_{40} K_{40}	N_0 P_{40} K_{80}	N_0 P_{80} K_{80}	N_{40} P_{80} K_{80}
1956	7.49	7.95	8.45	8.31	8.04	8.47	8.31
1957	9.14	8.39	8.81	10.16	9.24	9.50	9.33
1958	13.13	12.96	14.33	14.16	13.34	15.25	13.88

Results not significant.

No significant result was obtained in any of the above three years although the trend of yield of different treatments was rather consistent in each year. Therefore, the total yield figures of all the treatments from 1956-58 were analysed and the result is shown below:-

Table No. 6:

$N_0 P_0 K_0$	$N_{40} P_0 K_0$	$N_0 P_0 K_{40}$	$N_0 P_{40} K_{40}$	$N_0 P_{40} K_{80}$	$N_0 P_{80} K_{80}$	$N_{40} P_{80} K_{80}$
29·76	29·30	31·59	32·63	30·62	33·22	31.52

Difference required for significance at 5% = 2.33 mds.

It will be seen that over the above three years, combination of 80 lbs. of phosphate and 80 lbs. of potash (N_0P_{80} K_{80}) has produced the highest yield and has given significantly higher yield than $N_0P_0K_0$ (Check), $N_{40}P_0K_0$ (Nitrogen alone) and $N_0P_{40}K_{80}$. A combination of phosphate and potash with 40 lbs. each has also given significantly higher yield than $N_0P_0K_0$ and $N_{40}P_0K_0$.

From the results it appears that nitrogen has a tendency to depress the crop in this *bheel* soil. But combinations of phosphate and potash in equal proportions of 80 lbs. or 40 lbs. and in absence of nitrogen, significantly increase the yield over no manure and nitrogen alone.

Roopcherra N.P.K. Experiment—Expt. No. C. 2 :— This multi-level N.P.K. experiment was started in 1955 on Tingamira tea planted in 1949 at a spacing of 5 ft. × 2 ft. Shade trees are *Albizzia chinensis* planted 20 ft. × 20 ft. in 1949.

This experiment consists of two parts. In the first part there are three levels of 0 lb., 40 lbs. and 80 lbs. of each nitrogen, phosphate and potash and their combinations. In the second part

there are four levels of 0 lb., 20 lbs., 40 lbs. and 80 lbs. of each of phosphate and potash with a constant level of 80 lbs. nitrogen. Altogether there are 34 treatment combinations.

In 1958, the main effect of nitrogen only is highly significant as shown in the table below. The yield figures are in maunds of made tea per acre.

Table No. 7:

0 lb. nitrogen	...	14·97
40 lbs. nitrogen	...	15·42
80 lbs. nitrogen	...	16·30

Difference required for significance at 5% level = 0·76
at 1% level = 1·03

80 lbs. nitrogen has given significantly higher yield over 0 lb. and 40 lbs. nitrogen at 5% level. The increase over 0 lb. nitrogen is significant even at 1% level. There is, however, no difference between 40 lbs. and 0 lb. Neither the main effects of phosphate and potash nor the interactions of nitrogen, phosphate and potash are significant. In the second part significant results have been obtained. This is shown in the table below:—

Table No. 8 : Yields in maunds of made tea per acre.

$N_{80}P_0$	...	17·21	$N_{80}K_0$	...	16·66
$N_{80}P_{20}$	...	16·33	$N_{80}K_{20}$	...	15·93
$N_{80}P_{40}$	...	15·45	$N_{80}K_{40}$	...	16·44
$N_{80}P_{80}$	...	15·76	$N_{80}K_{80}$	...	15·72

Difference required for significance at 5% level = 0·87

In presence of 80 lbs. nitrogen, both phosphate and potash have a tendency to depress the yield. 80 lbs. nitrogen alone has given significantly higher yield than its combinations with all the doses of phosphate. It is also seen that when the dose of phosphate is increased from 20 lbs. to 40 lbs. per acre, there is a significant reduction in yield. All doses of potash in combination with 80 lbs. nitrogen have also reduced the yield when compared with 80 lbs. nitrogen alone. The reduction in yield

however, is significant only when a dose of 80 lbs. potash per acre has been added.

Sephinjuribheel T.E.—Expt. No. C.16.— This experiment was started on a *bheel* soil in 1951 by the Scientific Officer, Jokai (Assam) Tea Co. with our co-operation. The tea is a Burma type planted 4′ × 4′ triangular between 1933-36. The treatments are as follows:—

1. N_0 P_0 K_0	5. N_0 $P_{40}K_{80}$
2. N_{40} P_0 K_0	6. $N_{40}P_{80}K_{80}$
3. N_0 $P_{40}K_{40}$	7. N_0 $P_{80}K_{120}$
4. N_{40} $P_{40}K_{40}$	8. $N_{40}P_{80}K_{120}$

N denotes Nitrogen.
P ,, Phosphate.
K ,, Potash

Associated figures denote lbs. of nutrient per acre.

In 1958 the effects of treatments are significant. This is shown in the table below. The yield figures are in pounds of green leaf per treatment of three plots (219 bushes).

Table No. 9:

N_0 P_0 K_0	N_{40} P_0 K_0	N_0 P_{40} K_{40}	N_{40} P_{40} K_{40}	N_0 P_{40} K_{40}	N_{40} P_{80} K_{80}	N_0 P_{80} K_{120}	N_{40} P_{80} K_{120}
340	399	535	526	548	541	584	544

Difference required for significance at 5% = 56 lbs.

All combinations of Nitrogen, Phosphate and Potash have given significantly higher yields than no manure. The increases in yield given by the treatments involving phosphate and potash, however, are much greater than that given by nitrogen alone—the former ones having given significantly higher yield than the latter.

There is no significant difference between the treatments involving phosphate and potash except between N_0 $P_{80}K_{120}$ and $N_{40}P_{40}$ K_{40} where the difference is significant. In previous years also, N_0P_{80} K_{120} produced the highest yield.

WEST BENGAL ADVISORY BRANCH—DOOARS

R. I. MACALPINE—Senior Advisory Officer.
H. MITRA—Assistant Advisory Officer.

STAFF

Mr. R. I. Macalpine resumed his duties in the Dooars on 2nd April, 1958.

Mr. W. J. Grice who acted for the Senior Advisory Officer during his absence, proceeded to Darjeeling on 24th April, 1958 to reinstitute the office of Advisory Officer, Darjeeling and Terai.

Shri P.P. Lama arrived from Tocklai on 18th November 1958 after completing his training as Meteorological Assistant.

Shri P. Deb Roy arrived from Cachar on transfer on 20th December to take up the duties of 3rd Field Assistant.

TOURING

104 member gardens and 8 non-member gardens were visited by the Senior Advisory Officers, these figures included estates visited by Dr. A. R. Sen.

17 member gardens and 26 non-member gardens were visited by the Assistant Advisory Officer. A sum of Rs. 3,307/43 was received as advisory fees during the year from non-member gardens.

MEETINGS

The Acting Senior Advisory Officer attended the following meetings during the year.

Annual General Meeting of Terai Planters Association on the 2nd January, 1958; Annual General Meeting of the Dooars Branch Indian Tea Association on the 23rd January, 1958; General Committee Meeting of the Dooars Branch Indian Tea Association on 11th March, 1958; Annual General Meeting

of the Darjeeling Branch Indian Tea Association on the 15th March, 1958; General Committee of Scientific Liaison Committee of the Tea Board on 20th March, 1958. (This meeting was also attended by Mr. R. I. Macalpine and Mr. Mitra); Annual General Meeting of the Indian Tea Planters Association on 12th April, 1958.

Mr. Macalpine and Mr. Mitra attended the Tocklai Annual Conference from the 11th to 13th November, 1958.

LECTURES AND DEMONSTRATIONS

No lectures or demonstrations were given in 1958.

COURSES

The Acting Senior Advisory Officer gave three lectures and assisted in the demonstration at each of the lecture courses held at Tocklai from February 17th to 7th March.

PUBLICATIONS

Revised T. E. Serials on Planting of Shade, Green Crops and Stump planting of Shade were submitted during the year to Tocklai by the Senior Advisory Officer and have now been printed.

Memoranda on Requirements of Research in West Bengal, and Shade were also submitted to Tocklai by the Senior Advisory Officer and also a note on the Andaman and Nicobar Islands.

ADVISORY CORRESPONDENCE

573 letters and reports of an advisory nature were written.

TECHNICAL REPORTS

Helopeltis theivora :

By far the most outstanding features of the year under report were (i) the epidemic incidence of *Helopeltis theivora* particularly towards the end of the season, in certain localities in the District and (ii) the evidence of rapid spread of a creeper (*Mikania* sp) from the west to the east.

The former was responsible for considerable losses in back end crop. While action in a number of estates to control it was initiated early on (July/August) by the normally recommended methods of spraying with DDT, its spread was not effectively checked and the ravages of the pest gained such momentum as virtually to close down large areas of tea. Weather conditions were such during July and August as to make spraying ineffective. By the time weather conditions improved the pest had spread to such an extent as to make effective control, with the facilities normally available to estates, impracticable.

Mikania sp.:

Mikania which had hitherto not been reported to the West of the Toorsa was found in the Kalchini and Jainti Districts during the year and from reports from elsewhere appears rapidly to have invaded areas further east and even the south of West Bengal. A note on the creeper was circulated to members through the various Associations.

EXPERIMENTS

The Experiments listed below were continued during the year.

N.P.K. Manuring:

Kalchini T.E. (1954) and Ghatia T.E. (1957).

Nitrogen Manuring under Shade:

Baradighi T.E. (1956).

Times of Pruning:

Central Dooars T.E. (1955), Chuapara T.E. (1956), Bhogotpore T.E. (1957).

Pruning Cycles:

Baradighi T.E. (1955) and Chuapara T.E. (1956).

Cultivation Experiments:

Bhatpara T.E. (1957) and Chuapara T.E. (1957).

District Clonal Trial :

Nagrakata T.E. (1957) and Chuapara T.E. (1958).

These experiments are now the partial responsibility of the Agricultural Branch and results of interest are given in the Appendix prepared by the Senior Agriculturist.

Two new trials as under were initiated during the year:—

Pruning vis a vis Red Rust. Nya Sylee T.E.— A small scale trial wherein pruning of young tea in July/August as compared with pruning in January/February will be investigated has been initiated. It is considered that by pruning in July/August regrowth may be less liable to Red Rust infection as this will occur during a period when Red Rust sporulation does not occur to the same extent as in the early part of the season and laterals should therefore be relatively free of infection.

Shade Tree Experiment. Nya Sylee T.E.— Facilities over an area of some 12 acres were accorded in Nya Sylee T.E. for a trial on various species of shade trees, leguminous and non-leguminous. The following species are under trial.

Albizzia odoratissima.
Albizzia richardiana.
Albizzia lebbek.
Derris robusta.
Acrocarpus fraxinifolius.
Cassia siamea.
Chukrassia tabularis.
Dalbergia sericea.
Grevillia robusta.

STATION REPORT

Visitors :

Mr. H. Ferguson visited this Branch at the time of Terai Planters Association and D.B.I.T.A.. Annual General Meetings.

Mr. N. B. Chanda visited the Dooars from 4th—6th May.

Dr. M. J. Green, Selection Officer, visited West Bengal from 1st June to 1st July 1958.

Dr. A. R. Sen visited this Branch from 23rd—26th September.

M. Flemal from the Belgian Congo visited Nagrakata from 9th—16th December, 1958.

Administration :

The water supply for the Headquarters is now satisfactory as a result of the completion of the reservoir and pumping arrangements initiated.

The Meteorological Officer's Quarters and a third Field Assistant's Quarter located at Baradighi were completed during the year.

APPENDIX

AGRONOMIC EXPERIMENTS IN THE DOOARS

Nitrogen Manuring Experiments :

Baradighi T.E.—Expt. No. D.6.— This experiment was started in 1956. The tea is 41 years old Manipuri hybrid kind planted $4\frac{1}{2}' \times 4\frac{1}{2}'$ triangular. *Alibizzia odoratissima* shade trees are planted 45 feet apart and there are 6 shade trees in the border of each plot of 200 bushes.

As in 1957, the treatments failed to show any significant difference between them in 1958 also. The yields in maunds of made tea per acre of each treatment are given below.

Table 1 :

Treatment No.	Level of nitrogen per acre	Yield		Total	% Increase over check
		1957	1958		
1	0 lb.	21·12	19·08	40·20	...
2	40 lbs.	22·46	18·84	41·30	2·74
3	80 lbs.	23·15	19·43	42·58	5·92
4	120 lbs.	22·77	18·54	41·61	3·51

Result not significant.

N.P.K. Manuring Experiments :

Kalchini T.E.—Expt. No. D.1.— This experiment was started in 1954. The tea is Manipuri planted in 1928. In the first part of the experiment there are three levels of 0 lb., 40 lbs. and 80 lbs. per acre of each of nitrogen, phosphate and potash and their combinations. In the second part there are four levels—0 lb., 20 lbs., 40 lbs. and 80 lbs. of each of phosphate and potash with a constant level of 80 lbs. nitrogen.

In 1958 the main effect of nitrogen was significant, both 40 lbs. and 80 lbs. being significant over no nitrogen. The yield figures in maunds of made tea per acre are shown below :—

Table 2:

Levels of Nitrogen	Yield
0 lb.	17·23
40 lbs.	18·56
80 lbs.	19·35

Difference required for significance at 5% level = 0.24.

Main effect of phosphate and potash was not significant.

Nitrogen and potash interactions were significant this year. Yield in maunds of made tea per acre obtained from different levels and combinations of nitrogen and potash are shown in the table below:—

Table 3 :

Potash \ Nitrogen	0 lb.	40 lbs.	80 lbs.
0 lb.	17·02	18·76	18·66
40 lbs.	18·16	18·22	19·23
80 lbs.	16·50	18·71	20·17

Difference required for significance at 5% level = 1.36.

It is seen that in absence of nitrogen, 80 lbs. of potash gave lower yield than 40 lbs. of potash. But a combination of 80 lbs. nitrogen and 80 lbs. potash gave the highest yield and was significant over 80 lbs. nitrogen without potash.

In the nitrogen, phosphate and potash interactions, it was found that the combinations of 80 lbs. nitrogen, 40 lbs. potash and no phosphate ($N_{80}P_0 K_{40}$) and 80 lbs. each of nitrogen, phosphate and potash ($N_{80} P_{80} K_{80}$) gave significantly higher yield than 80 lbs. of nitrogen alone.

At the level of 80 lbs. nitrogen per acre, there are four levels of phosphate and potash; these are 0 lb., 20 lbs., 40 lbs. and 80 lbs. per acre. No significant result has been obtained in this part.

WEST BENGAL ADVISORY BRANCH—DARJEELING AND TERAI

W. J. GRICE—Advisory Officer.

STAFF

Mr. W. J. Grice acted, in his absence, for Mr. R. I. Macalpine the Senior Advisory Officer, West Bengal at the Nagrakata Head Quarters until his return at the beginning of April. Mr. Grice then proceeded to Darjeeling on the 24th April, to re-open Darjeeling and Terai Advisory Branch.

Shri R. M. Gurung, Field Assistant, finished his training at Tocklai during the year and arrived in Darjeeling on the 31st April. After assisting in moving the office he moved to the Rungbong Valley sub-district and took over the supervision of garden experiments in this district.

Shri K. B. Mukhia, Meteorological Assistant, finished his training at Tocklai during the year and arrived on 11th April, in Darjeeling from Nagrakata, where he had been preparing the meteorological station. He is resident on Nagri Farm T. E. where the Darjeeling meteorological station is situated.

Shri S. D. Syangdon was appointed temporarily on the 19th May as Clerk/Typist until the return of Miss S. Subba. Miss Subba is expected to return early in January, 1959.

TOURING

During the year a total of 128 visits were made, by the Advisory Officer, to gardens in Darjeeling, Dooars, Terai and Assam. In Darjeeling 49 visits were paid to member gardens and 15 to non-member, in the Dooars 41 visits were paid to member gardens and 2 to non-member, and in the Terai 17 visits were paid to member gardens. In addition two gardens in Assam were visited twice during the lecture courses.

In the last quarter the Advisory Officer toured the Tea Districts in Ceylon and visited 9 gardens and spent 3 days at the Tea Research Institute of Ceylon.

MEETINGS

The Advisory Officer attended the following meetings during the year:—Annual General Meeting of the Terai Planters Association, 22nd January: Annual General Meeting Dooars Branch Indian Tea Association, 23rd January: General Committee Meeting of the Dooars Branch Indian Tea Association, 11th March: Annual General Meeting of the Darjeeling Branch Indian Tea Association, 15th March: A Meeting of the General Committee Dooars Branch I.T.A. and the Scientific Liaison Committee of the Tea Board, 20th March: The Annual General Meeting of the Indian Tea Planters' Association, 12th April, this meeting was addressed by the Advisory Officer.

The Advisory Officer attended the Tocklai Annual Conference on 11th—13th November and attended a Symposium on Tea Rehabilitation and Replanting that was held in Colombo, at the Colombo Chamber of Commerce, on the 28th November.

LECTURES AND DEMONSTRATIONS

Nothing to report.

COURSES

The Advisory Officer gave three lectures and assisted in the demonstrations at each of the lecture courses held at Tocklai from February 17th to March 7th.

ADVISORY CORRESPONDENCE

Approximately 231 letters and reports of an advisory nature were written during the year.

PUBLICATIONS

The Advisory Officer wrote a short article on "Red Rust in the Darjeeling District" which was issued to Darjeeling gardens.

TECHNICAL REPORTS

The weather during 1958 in the district has been most abnormal. This led to a change in the normal crop distri-

bution and also to abnormally heavy attacks of several pests and diseases.

The total rainfall during the 1958 season has not been far removed from the average. Its distribution has, however, been abnormal and it is this that has led to the peculiar crop distribution and heavy incidence of pest and disease attack.

An unusually high amount of rain fell at the end of April and beginning of May. This together with warm weather towards the end of May encouraged growth, and most gardens made above normal crops in May. In June the crop was below normal due to the late arrival of the monsoon.

During July, August and the first week in September the district as a whole experienced cold, damp, misty weather, which led to an abnormally high incidence of blister blight, and this disease was reported from gardens that rarely experience it. The continual bad weather and heavy blister led to gardens producing well below average crops during these months, and most gardens at the end of September were well below their estimates. One garden had to stop plucking for two days during August. During September and early October tea mosquito (*Helopeltis theivora*) was serious on a number of gardens, this was probably due to the bad weather.

In October and early November many estates made above normal crops, which meant that the district as a whole was not so behind in crop as originally expected.

Towards the end of the year Red spider attack was fairly severe in a number of gardens.

EXPERIMENTS

The following experiments, initiated in the year shown against each, were continued.

Nitrogen Manuring Experiments:

Happy Valley T.E. two experiments (1957).

Singell T.E. (1957) and Selimbong T.E. (1957).

N. P. K. Manuring Experiments:

Margaret's Hope T.E. (1940), and Rungneet T.E. (1954).

Times of Pruning Experiments:

Puttabong T.E. (1953).

Pruning Cycle Experiments:

Nagri Farm T.E. (1951), and Mim T.E. two experiments (1950).

These experiments are now the partial responsibility of the Agricultural Branch and results of interest are reported in the appendix below.

STATION REPORT

Visitors:

The following have visited the branch since it was re-opened in April.

N. S. Coldwell Esqr., Chairman, Scientific Sub-Committee on the 31st May and again during the Puja holidays in October, on the second visit the future residence of the Advisory Officer Kenmure point, was inspected.

Dr. N. B. Chanda visited the branch from the 28th April to 3rd May and visited a number of gardens.

R. I. Macalpine Esqr., Senior Advisory Officer, West Bengal from the 4th—8th July, 4th—8th October and on the 24th December.

Mr. M. J. Green visited Darjeeling and Terai from 4th to 7th June and toured a number of estates carrying out selection work.

Dr. A. R. Sen, Senior Statistician and Mr. S. Basu, Assistant Agriculturist from 27th September to 6th October. During this visit they toured all the Darjeeling garden experiments with the Advisory Officer.

Mr. H. Mitra, Assistant Advisory Officer, West Bengal visited the branch from 23rd November to 1st December and toured 8 gardens.

On the 18th December the Advisory Officer took a Russian Tea Delegation of 5 namely: Mr. Nicolai T. Rosinishvili, Mr. Nicolai V. Lachritsk, Mr. Konstontin I. Djalagania, Mr. Adolf V. Khourodze and Mr. Vitolii Koutchouk, to Ging and Happy Valley T. E.

Prior to the re-opening of the station the Director visited Darjeeling to attend the Annual General Meeting of the Darjeeling Branch and visited a number of gardens at the same time.

Meteorological :

The site for the Meteorological Station at Nagri Farm T. E. was prepared and installation of the instruments was almost completed by the end of the year. Recording is expected to start early in January, 1959.

Office :

The office of the branch was opened towards the end of May and is situated opposite the office of the Secretary, D.B.I.T.A. in a room that has kindly been made available by the D. & D.M.A. There is no doubt that in Darjeeling it is more convenient for both planters and Advisory Officer to have the office situated in the town rather than on a garden.

Accommodation :

The Advisory Officer for the first few months after his arrival searched the town for suitable accommodation. Early in July a Cooch Behar house, Kenmure Point, fell vacant and the Association made an offer which was accepted. However there has been some trouble in drawing up the agreement as the title deeds had been lost. It is hoped the agreement will be finalised early in 1959 so that repairs can be started. Since his arrival the Advisory Officer has been living in the Planters' Club.

APPENDIX

AGRONOMIC EXPERIMENTS IN DARJEELING

Nitrogen Manuring Experiments :

Happy Valley Tea Estate—Expt. No. Dj. 15 :— The object of the experiment is to study the effect of nitrogen on crop distribution and total yield when applied as sulphate of ammonia at different times of the year.

The tea is old China situated at an elevation of 5150 ft. above sea level in a South-West aspect. A four year pruning cycle is followed. In 1958, the first year of treatment application, the tea was skiffed. The treatments are—

Treatment Nos.

1. 40 lbs. nitrogen per acre in March.
2. 40 lbs. nitrogen per acre in July.
3. 40 lbs. nitrogen per acre in March and another 20 lbs. nitrogen per acre in end July.

The following table shows the yield in maunds of made tea per acre of the treatments.

Table No. 1 :

Treatment	Yield
1	7·9
2	6.8
3	7·6

Difference required for Significance at 5% level = 0·71 mds.

Treatments 1 (40 lbs. nitrogen in March) and 3 (40 lbs. nitrogen in March and 20 lbs. nitrogen in July) have given significantly higher yield than Treatment 2 (40 lbs. nitrogen in July). There was, however, no significant difference between Treatments 1 and 3.

The whole season's yield figures were split for second flush, main and back-end crops to see the effects of treatment

on crop distribution. In the second flush both Treatments 1 and 3 which received 40 lbs. nitrogen in March produced higher yield than Treatment 2 which did not receive any manure till July. But Treatment 2 (40 lbs. nitrogen in July) also failed to increase the yield of both rain and back-end crops over Treatments 1 and 3. Treatment 3, however, increased the yields of both rain and back-end crops over the other treatments. The plots under this treatment received an application of 20 lbs. nitrogen in July on top of 40 lbs. in March.

From the first year's results it appears that application of 40 lbs. nitrogen in March gives more yield than 40 lbs. nitrogen in July. An additional dose of 20 lbs. nitrogen over and above 40 lbs. nitrogen in March does not increase the total yield but gives more yield in the main and back-end crops. As this was the first year of the experiment, it is too early to see what residual effect the application of 20 lbs. nitrogen in July will have in the early crop the following year. In any case, it is too early to come to any definite conclusions yet.

Happy Valley Tea Estate—Expt. No. Dj. 12 :— The object of this experiment is to study the effect of increasing doses of nitrogen applied in the form of sulphate of ammonia on the yield and quality of made teas.

The tea is old China situated at an elevation 5,900 ft. above sea level in a South-West aspect. A four year pruning cycle is followed. In 1958, the first year of treatment application, the tea was skiffed. The treatments are:—

Treatment Nos.

1. No. nitrogen (Check).
2. 30 lbs. nitrogen per acre annually.
3. 60 lbs. nitrogen per acre annually.
4. 30 lbs. nitrogen per acre in the 1st. year.
   40 lbs. ,, ,, ,, ,, 2nd. year.
   50 lbs. ,, ,, ,, ,, 3rd. year.
   60 lbs. ,, ,, ,, ,, 4th. year.

In 1958 no manufacture could be done and therefore only yield figures were analysed.

The following table shows the yields in maunds of made tea per acre of the treatments:—

Table No. 2:

Treatment Nos.	Yield
1	6·84
2	7·18
3	8·36
4	7·76

Difference required for significance at 5% level = 0·95 mds.

Significant differences in yield have been obtained. Treatment 3 (60 lbs. nitrogen per acre) has given the highest yield and is significant over treatment 2 (30 lbs. nitrogen per acre) and Treatment 1 (No nitrogen). There was no significant difference between Treatments 3 and 4 or between 4, 2 and 1.

The whole season's crop yields were split for second flush crop, main crop and back-end crop to see the effect of Treatments on the crop distribution. It was found that in all cases Treatment 3 (60 lbs. nitrogen) gave the highest yield. Treatment 2 and 4 (both received 30 lbs. nitrogen per acre in 1958) also gave higher yield than Treatment 1 (No nitrogen) in the first two seasons i.e. in the second flush and main crops. At the back-end comparatively lower yields were obtained but Treatment 3 (60 lbs. nitrogen per acre) still showed its beneficial effect.

No final conclusions can be drawn now but it appears that under the conditions of the experiment 60 lbs. nitrogen per acre increases the yield over no nitrogen and 30 lbs. nitrogen per acre. Its beneficial effect is also seen in the first and second flush, main and back-end crops.

Pruning Cycle Experiments:

Nagri Farm Tea Estate—Expt. No. Dj. 8.— The experiment was started in 1951 to study the effects of annual and biennial pruning systems on the yield and crop distribution of tea at an elevation of about 4,000 ft. above sea level. The tea is Betjan planted between 1921-1927 at a spacing of 4′ × 4′ on the contour.

The following table summaries the results from 1951-1958.

Table No. 3: Yield in ozs. of green leaf per treatment.

Treatment \ Year	1951	1952	1953	1954	1955	1956	1957	1958	Total
Annual	1547 P	1266 P	1272 P	1680 P	1273 P	2545 P	1857 P	2089 P	13,487
Biennial ...	1543 P	1872 U.P.	1296 P	2154 U.P.	1236 P	2638 U.P.	1875 P	3685 U.P.	16,302
C. D. (P= .05) ...	N.S.	184	N. S.	141	N. S.	N. S.	N. S.	222	

P = Pruned ; U.P. = Unpruned ; N. S. = Not Significant.

In eight years, from 1951 to 1958, the biennial prune has recorded an increase in yield to the extent of 20.9% over the annual prune. With the exception of the year 1956, it will be seen that the yield following an unpruned year in the biennial prune, is significantly higher than the annually pruned tea whereas there is no significant difference between the yields in any year when the tea under both the treatments was pruned. Therefore the total increase in yield over the annual prune is mainly due to the increased yield obtained during the unpruned years of the biennial prune. Again, it has been seen that this increase in yield during the unpruned years of the biennial prune has almost entirely been due to the first and second flush crops which the annually pruned tea is always deprived of. This is seen in the table below where the percent periodic crop distribution on seven years' cumulative yield from 1952-1958 has been taken into consideration.

Table No. 4: Percent periodic Crop Distribution—(1952-1958).

Periodic Crops	Annual	Biennial
1st. flush	0·35	5·93
2nd. flush	8·67	11·83
Main crop { Early	21·38	23·25
Main crop { Late	14·37	14·22
Total	44.77	55·23 = 100

From the eight years' results of this experiment it may now be concluded that under the conditions of the experiment:—

(*a*) Biennially pruned tea gives more yield than the annually pruned.

(*b*) The yield of tea in the unpruned years is more than the pruned years.

(*c*) The increase in yield during unpruned years is mainly due to first and second flush crops which the annually pruned tea is deprived of.

Mim Tea Estate—Expt. Dj. 6 :— 1958 was the ninth year of the experiment. In this year significant results have been obtained and the yield figures of each treatment in ozs. of green leaf are given below.

Table No. 5:

Treatment	How Pruned/Skiffed	Yield
1 (Biennial)	Pruned	624
2 (Triennial A)	Unpruned	744
3 (Triennial B)	Light Skiff	759
4 (Triennial C)	Unpruned	832
5 (Quadrennial)	Pruned	551

Difference required for significance at 5% level = 131.

Plots of treatments 4 and 3 which were left unpruned and light skiffed respectively gave significantly higher yield than plots of treatments 1 and 5 which were pruned. Plots of treatment 2 were also left unpruned and gave higher yield than plots of treatments 5 and 1 but the increase was significant only over treatment 1. There was no significant difference between treatments 4, 3 and 2 and between 5 and 1. Similar results were obtained in previous years also. The comparatively low yield of skiffed and unpruned plots this year is most likely due to severe hail damage in April.

In 1958, the three triennial prunes have completed three cycles and hence, can be compared with each other. Generally speaking, skiffed or unpruned years in these three cycles gave much higher yield than the pruned years. No significant differences between them were obtained in any year. In short, the trend of yield of the three triennial prunes is very similar in every year. Below is given the total yield in ozs. of green leaf of the cycles from 1951 to 1958.

Table No. 6:

Treatments	Yield
Triennial A (P - U.P. - U.P.)	8948
Triennial B (P - U.P. - L.S.)	8438
Triennial C (P - L.S. - U.P.)	8782

N.B.: P = Prune, U.P. = Unprune, L.S. = Light Skiff.

It will be seen that the difference between them is small. However, Triennial A which has two unpruned years in the cycle has given the highest yield and this shows that after prune, in the next two years if the tea is neither pruned nor skiffed (except possibly a levelling off skiff) there is no loss in crop but may be a slight gain.

The biennial prune completed four cycles in 1957 and in 1958 it finished the 1st. year of the fifth cycle. Its total yield over a period of nine years *i.e.* from 1951 to 1958 is 8682 ozs. Both Triennial 'A' and 'C' have given more yield but Triennial 'B' has given slightly less yield than this cycle. There are, however, indications that in comparison to unpruned or skiffed tea, pruned tea gives a much lower yield of the more valuable first and second flush crops. Therefore, the biennial prune having more frequent pruning in its cycle than the triennial prunes, seems not likely to be very suitable in the elevation where the experiment is situated.

The quadrennial prune has so far given the highest cumulative yield but as it has not yet completed three cycles no valid comparisons can be made with the other treatments just now.

Mim Tea Estate—Expt. No. Dj. 7.— In 1958 no significant differences between the treatments have been obtained. In this year plots of Treatment 3 were light skiffed and plots of Treatments 2 and 4 left unpruned but unlike what has been seen in previous years, they failed to give significantly higher yields than plots of Treatments 5 and 1 which were pruned. The yields of different treatments in ozs. of green leaf are given below.—

Table No. 7 :

Treatment	How Pruned/Skiffed	Yield
1	Pruned	649
2	Unpruned	749
3	Light Skiffed	763
4	Unpruned	733
5	Pruned	670

Results not significant.

It may, however, be noted that unpruned or light skiffed plots have given a slightly increased crop than the pruned plots. In April, 1958 the tea in the experimental area was severely struck by hail no less than four times. It is most likely that skiffed and unpruned plots were more severely damaged than the pruned plots and consequently very low yields, in comparison to other years, have been obtained from the unpruned and skiffed plots.

In 1958 the three triennial prunes have completed three cycles and therefore can be compared with each other. Generally speaking, skiffed or unpruned years in these three cycles gave much higher yield than the pruned years. No significant

differences between them were obtained in any year. In short. the trend of yield of the three triennial prunes is very similar in every year. Below is given the total yield in ozs. of green leaf of the cycles from 1951 to 1958.

Table No. 8:

Treatment	Yield
Triennial A (P - U.P. - U.P.)	8824
Triennial B (P - U.P. - L.S.)	8779
Triennial C (P - L.S. - U.P.)	8458

N.B.—P = Prune
U.P. = Unprune
L.S. = Light Skiff

It will be seen that the difference between them is very small indeed. However, Triennial 'A' which has two unpruned years in the cycle has given the highest yield and this shows that after prune, in the next two years if the tea is neither pruned nor skiffed (except possibly a levelling off skiff) there is no loss in crop but may be a slight gain.

The biennial prune completed four cycles in 1957 and in 1958 it finished the 1st. year of the fifth cycle. This pruning cycle has yielded 9190 ozs. over a period of 9 years *i.e.* till 1958. The percentage increase over the triennial prunes are as follows: —

Table No. 9 : % increase by the Biennial prune over Triennial prunes.

Triennial Treatments	% increase of biennial prune
1. Triennial 'A'	4.15
2. Triennial 'B'	4.68
3. Triennial 'C'	8.65

The reason for this higher yield is that except in the first year, the biennial prune maintained a comparatively higher level of yield in the pruned years also. On the other hand, in all the triennial prunes pruning was followed by a steep drop in yield. However, it may be mentioned that in spite of its slightly higher yield, the biennial prune is deprived of the more valuable first and second flush crops more than the triennial prunes due to pruning in every alternate year.

The quadrennial prune has so far given the highest cumulative yield but as it has not yet completed three cycles, no valid comparisons can be made with the other treatments just now.

N.P.K. Manuring Experiments:

Rungneet Tea Estate—Expt. No. Dj. 11.— This experiment was started in 1954. It consists of two parts. In the first part there are three levels each of nitrogen, phosphate and potash. The levels are 0 lb., 40 lbs., and 80 lbs. per acre and the total number of treatment combinations is 27. In the second part there are four levels of each of phosphate and potash 0 lb., 20 lbs., 40 lbs. and 80 lbs. with a constant level of 80 lbs. nitrogen. Altogether there are 34 treatment combinations with two replications.

In 1958, only the main effect of nitrogen is highly significant as is shown in the table below. Yield figures are in maunds of made tea per acre.

Table No. 10 :

Levels of Nitrogen	Yield
0 lb.	3·69
40 lbs.	5·00
80 lbs.	7·00

Difference required for significance at .01% = 0.31

It will be seen that the increases obtained from nitrogen application have been strongly linear. With the increase in level of nitrogen there has been significant increase in yield.

Responses to the main effects of phosphate and potash are not significant.

This year, only the nitrogen and potash interactions are significant in the first part. This is shown in the table below. Yield figures are in maunds of made tea per acre.

Table No. 11 :

N \ K	K_0	K_{40}	K_{80}
N_0	3.92	3.43	3.72
N_{40}	4.96	5.77	4.25
N_{80}	7.29	6.72	6.97

Difference required for significance at 5% level = 0.91

It is seen that 80 lbs. potash has a tendency to depress the crop yield at all the levels of nitrogen and at 40 lbs. nitrogen it has actually given significantly lower yield than 40 lbs. potash. There is also no significant response from 40 lbs. potash over and above the respective levels of nitrogen alone.

In presence of 80 lbs. nitrogen per acre the main effect of phosphate only is significant. The yield figures in maunds of made tea per acre are given below.

Table No. 12 :

Treatments		Yield
N_{80} P_0	...	6.68
N_{80} P_{20}	...	6.75
N_{80} P_{40}	...	7.86
N_{80} P_{80}	...	7.52

Difference required for significance at 5% level = 0.39

Both N_{80} P_{40} and N_{80} P_{80} have given significantly higher yield than N_{80} P_{20} and N_{80} P_0. There is, however, no significant difference between the first two and between the second two treatments.

INDIAN TEA ASSOCIATION (LONDON)

CHEMICAL LABORATORY

BUTLER'S WHARF

E. A. H. ROBERTS—Research Manager.

MRS. M. MYERS—Chemist.

D. W. RUSTIDGE—Chemist.

STAFF

Dr. D. W. Rustidge was appointed to the staff with effect from December 1st., 1958. Mrs. Myers is continuing on a part-time basis, in lieu of a Technical Assistant.

Dr. E. A. H. Roberts visited Tocklai from October 28th to November 13th for discussions with Dr. Bhatia and to attend the Annual Conference. The opportunity was also taken of studying recent developments in Tea Manufacture.

RESEARCH AND EXPERIMENT

QUALITY AND CHEMICAL COMPOSITION

Effects of time and temperature of fermentation on theaflavin and thearubigin contents :

C. T. C. teas were manufactured at Tocklai, with times of fermentation varying from one to five hours. Six sets of teas were manufactured throughout the season of 1958. The results of analyses of these teas are given in Table 1. The teas were infused for ten minutes at 100°C and the theaflavin and thearubigin contents expressed as percentages by weight of the tea infused (uncorrected for moisture). This method of extraction is more reproducible than the standard method of five minute infusion in tasting cups, and also results in a considerably greater extent of extraction.

Table 1.

% Theaflavins

Date manufactured	Time of fermentation (hours)					
	1	2	3	4	5	Average
10/7/58	1.62	1.51	1.43	1.39	1.20	1.43
31/7/58	1.80	1.55	1.48	1.53	1.38	1.55
27/8/58	1.67	1.45	1.33	1.18	1.18	1.36
28/8/58	1.45	1.51	1.26	1.23	1.11	1.31
4/9/58	1.38	1.30	1.11	1.02	1.00	1.16
18/9/58	1.74	1.45	1.43	1.29	1.17	1.41
Average	1.61	1.46	1.34	1.27	1.17	

% Thearubigins

10/7/58	13.3	17.8	18.7	17.7	18.1	17.1
31/7/58	13.5	15.9	17.4	19.3	18.1	16.8
27/8/58	13.4	16.7	16.5	16.7	17.4	16.1
28/8/58	12.1	16.1	15.3	15.6	17.8	15.4
4/9/58	12.2	15.1	15.7	15.4	15.7	14.8
18/9/58	13.8	15.4	15.9	15.6	15.4	15.2
Average	13.0	16.2	16.6	16.7	17.1	
Average Thearubigin / Theaflavin	8.1	11.1	12.4	13.1	15.4	
Average D.C.	0.77	0.56	0.50	0.47	0.42	

The average values for each date of manufacture show a downward trend as the season advances. This is in accordance with general experience.

In conventionally manufactured teas (Ann. Report, 1956) the theaflavins reach their maximum level after about two hours fermentation. In these C.T.C. manufactured teas the theaflavin contents, with one exception, decrease progressively with time of fermentation. The time for maximum level of theaflavins cannot be determined exactly from the above results but is probably rather more than one hour. This more rapid fermentation is characteristic of C.T.C. manufacture.

During the second hour of fermentation the thearubigins increase appreciably whilst the theaflavins fall from an average of 1.61 to 1.46%. Over the rest of the five hour fermentation period there is a slight but significant rise in thearubigins and a steady fall in theaflavins. These results support the view that thearubigins are produced, at least in part, as a result of further oxidation of theaflavins.

The teas were also tasted. The average marks for liquor characters given by a London taster are recorded in Table 2.

Table 2.—Time of fermentation (hours)

	1	2	3	4	5
Colour	3.7	4.2	3.3	2.2	1.0
Strength	0.3	4.2	3.3	2.7	2.0
Quality	3.2	4.3	3.3	2.4	0.5
Briskness	2.5	4.7	3.3	2.5	0.0

The teas fermented for one hour were sometimes commended for their superior tone of colour, but scored less than the two hour teas on account of their inferior depth of colour. A "raw" pungency detracted from the value of the one hour teas.

The first four sets of teas were tasted together, and those manufactured on 31st July, 1958 were picked out as superior to the others. When the last two sets of teas were tasted preference was given to those manufactured on 18th September, 1958. In

both cases these preferences were for the teas with the highest theaflavin contents.

The preference shown for colour after two hours fermentation is highly significant. Taking into account the very favourable reports on the teas fermented for two hours on 31st July, 1958 and 18th September, 1958 it is concluded that the highest marks for colour, in this experiment, were given for a ratio of thearubigins to theaflavins of 10:1. Higher ratios than this, although giving more coloury teas, received lower marks on account of the inferior tone. Lower ratios were not liked as the teas were then too thin, with an unfermented character. A rough guide to this 10:1 ratio is provided by the distribution coefficient, which measures the ratio of colours in the two layers when a tea liquor is extracted with an equal volume of ethyl acetate or methylisobutylketone. A distribution coefficient (D.C.) of 0.6 corresponds with the 10:1 ratio, and such a measurement could be used as a guide to the most desirable time of fermentation.

It is important to emphasise that these conclusions apply only to C.T.C. teas of the type investigated, and it must not be assumed that a 10:1 ratio will be desirable for all teas. There are indications that a 16:1 ratio is satisfactory for blended teas. In many commercial teas the ratio is as high as 25:1, and in extreme cases a ratio of 65:1 has been measured. A blend of such teas with a C.T.C. tea with a 10:1 ratio would represent a satisfactory mixture.

Comparision of the analytical and tasting results again shows that the theaflavins contribute proportionally more than the thearubigins to strength. In the latter stages of fermentation, when thearubigins are still increasing slowly, the marks for strength are falling significantly. It would appear that the fall in strength due to the reduction in theaflavin content outweighs the increase which should result from the higher thearubigin content.

Neither the liquor character, quality, nor briskness are completely determined by theaflvain and thearubigin contents,

in fact it is probable that quality will not be adequately understood until we know much more about the volatile substances in tea. Nevertheless it would appear that there is some link in these results between the losses in quality and briskness with increasing time of fermentation, and the corresponding fall in the theaflavin content.

Creaming down :

A Legg-cut tea was chosen which was known to cream down well. 30 g. of this tea was extracted for 5 minutes with 750 ml. boiling distilled water. Theaflavins, thearubigins and caffeine contents were measured in one portion of the extract, the remainder was allowed to cream down. The cream formed was separated by centrifuging. Analyses by paper chromatography showed that it contained thearubigins and both theaflavins, but only inconsiderable amounts of bisflavanols and unoxidised ploypheno1s. The filtrate left after the separation of the cream was then analysed for theaflavins, thearubigins and caffeine with the results shown in Table 3.

Table 3.

	% by weight of tea extracted.		
	Theaflavins	Thearubigins	Caffeine
Original tea extract ...	1·48%	12·8%	2·78%
Extract after removal of Cream	0·56%	9·2%	1·80%
% precipitated as cream ...	62	28	35

These results establish that the cream contains caffeine, theaflavins and thearubigins. It has also been shown that a certain amount of pectin is also present.

The precipitate with 1% sulphuric acid:

The cream deposited by a tea extract on cooling is very finely dispersed. Even after centrifuging, the supernatant liquid is often cloudy and a sharp separation of cream from filtrate is

difficult to obtain. Addition of strong sulphuric acid (1 ml. per 100 ml. liquor) produces a more copious precipitate, of coarser grain, which settles down much more readily. Paper chromatographic analyses show that this precipitate, like cream, contains both theaflavins and thearubigins. The precipitate, as is evident from the results given in table 4 contains more theaflavins and thearubigins than the cream.

Table 4.

	% by weight of tea extracted.	
	Theaflavins	Thearubigins
Original tea extract	1·39%	13·2%
Filtrate after creaming down	0·80%	9·2%
Filtrate after precipitation with 1% sulphuric acid	0·62%	7·0%

Experience has shown that the extent of precipitation by 1% sulphuric acid is correlated closely to the ability of the tea to cream down. The amount of polyphenolic material (theaflavins and thearubigins) precipitated by 1% sulphuric acid can be estimated by titration with alkaline permanganate. The titre, in ml. 0.1 M permanganate per gm. of tea was previously referred to as the condensation index. This was due to the mistaken belief that the amount of polyphenolic material precipitated furnished an empirical measure of the degree of condensation-polymerisation which had taken place. As the titration appears to measure the ability of the tea to cream down it will in future be referred to as the "cream index".

Effect of caffeine content on the cream index:

Using a standard extract of 15 gm. tea in 375 ml. boiling distilled wter, the effects were studied of adding caffeine equivalent to 4% by weight of the tea taken, of removing caffeine by extraction with chloroform, and of a subsequent replacement of the caffeine extracted by the chloroform. In each case

theaflavins and thearubigins were estimated before and after precipitation with 1% sulphuric acid. The results are expressed as percentages of the total theaflavin and thearubigin precipitated.

Table 5

	% precipitated by 1% sulphuric acid.	
	Theaflavins	Thearubigins
Original tea extract	70	48
With 4% added caffeine	83	61
After chloroform extraction	15	13
After chloroform extraction and replacement of caffeine extracted	68	42

This experiment clearly shows that the extent of precipitation of theaflavins and thearubigins by 1% sulphuric acid is dependent upon the amount of caffeine in the extract.

The tea liquor used above was much stronger than the usual taster's extract. However very similar results were obtained with standard tasting extracts. The effects of varying caffeine content added to such an extract are shown in Table 6. The extract free from caffeine was obtained by shaking it with several successive portions of chloroform.

Table 6.

Caffeine content % by weight of tea	% Theaflavins precipitated by 1% H_2SO_4	% Thearubigins precipitated by 1% H_2SO_4	Cream Index.
0·0	8	8	9.8
2.42	46	29	25.6
4.42	60	35	31.6
6·42	64	40	40.2
8·42	68	44	40.2

These results are also illustrated in Figure I.

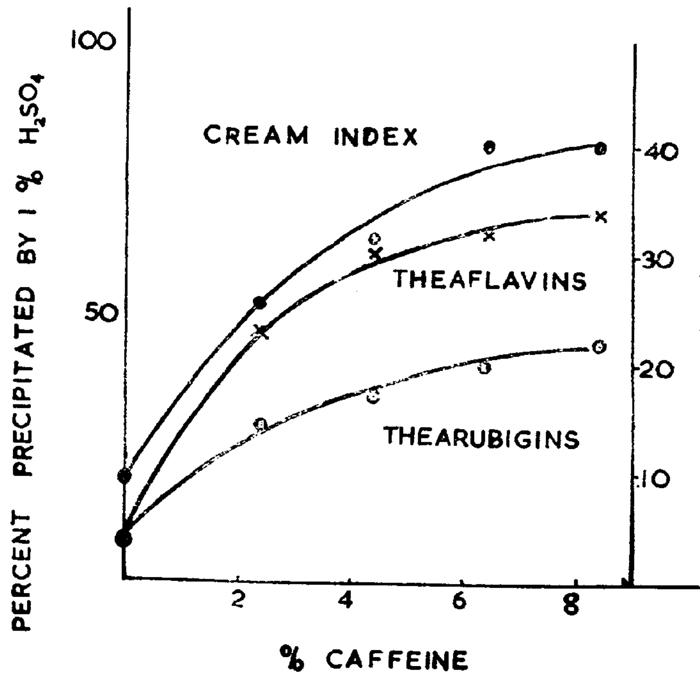


Figure I: *Effect of caffeine content on "Cream Index" and percentage precipitation by 1% sulphuric acid of theaflavins and thearubigins.*

The extent of precipitation by 1% sulphuric acid (and of creaming down) is distinctly less than with the strong extracts previously considered. However, as with the stronger extracts, the amount of theaflavins and thearubigins precipitated is very dependent upon the amount of caffeine present.

Both in these experiments and in those with stronger extracts the amount of caffeine precipitated is much less than on creaming down. This apparent anomaly is due to the solubility of caffeine in 1% sulphuric acid. It is probable that much of the caffeine is originally precipitated as complexes with theaflavins and thearubigins but that the acid subsequently

breaks up these complexes so that the caffeine goes back into solution. In support of this view it has been shown that treatment of precipitated cream with 1% sulphuric acid results in the extraction of much of the caffeine leaving the theaflavins and thearubigins undissolved.

Effects of fermentation time on cream index :

The effects of increasing time of fermentation are illustrated in Table 7 which gives results for teas which had been fermented for one, two and five hours. These were conventional teas and the experiments were carried out with standard Taster's extracts. Theaflavin and thearubigin contents were estimated before and after precipitation with 1% sulphuric acid; the cream index was also measured.

Although the percentage of the theaflavins precipitated always exceeded the percentage of thearubigins precipitated, the much higher contents of thearubigins resulted in the precipitate containing appreciably more thearubigin than theaflavin. It is the thearubigin content of the tea, therefore, which is the main factor determining the amount of precipitation. The ratio of thearubigins to theaflavins increases progressively throughout fermentation and in consequence, not only the extent of precipitation, but also the ratio of thearubigin to theaflavin in the precipitate, increases with time of fermentation.

Table 7

		Hours fermented		
		1	2	5
% Theaflavins	Before precipitation	0·53	0.77	0.53
	After precipitation	0·40	0.40	0.29
	Precipitated	0·13(24%)	0.37 (48%)	0.24 (45%.)
% Thearubigins	Before precipitation	4·95	12.1	14.8
	After precipitation	4·29	7.5	8.3
	Precipitated	0·66(13%)	4.6 (38%)	6.5 (44%)
Ratio $\frac{\text{Thearubigin}}{\text{Theaflavin}}$ in original extract		9·3:1	15.7:1	27.9:1
Ratio in 1% H_2SO_4 precipitate		5·1:1	12.4:1	27.1:1
Cream index		10·8	40.5	64.8

A tea with a high cream index will cream down well, but the cream will contain a relatively high proportion of thearubigins and its colour will be muddy. From the taster's point of view an ability to cream down well is desirable, but it is also desirable that the colour of the cream should be attractive. A high sum total of thearubigins will give a tea which creams down well, but this cream will have an undesirable muddy colour if the ratio of thearubigins to theaflavins is too high. The taster's observations on creaming down are therefore seen to be a method of estimating by eye the thearubigin and theaflavin contents of a tea.

FUNDAMENTAL CHEMISTRY

The chemical structure of theaflavins:

In the previous Annual Report a tentative structure for theaflavin was advanced. The establishment of such a structure cannot be an easy task and it is likely to be some time before this structure, or an alternative, can be regarded as fully established. However, during the last year evidence has been obtained which supports the views advanced.

A method has become available (T. Swain & W. E. Hillis, J. Sci. Fd. Agric., 1959, **10,** 63) for the estimation of undeactivated phloroglucinol nuclei in substances. The results obtained were in agreement with theaflavin gallate containing two such nuclei per molecule, in conformity with the structure proposed.

Theaflavins may be considered to be derivatives of purpurogallin, and a preliminary study of the infra-red absorption spectrum of theaflavin has revealed bands characteristic of purpurogallin. This must be regarded as useful supporting evidence.

The depsides of tea:

In addition to chlorogenic acid it has been claimed that tea contains other depsides, *p*-coumarylquinic acid and galloylquinic acid (theogallin). The already very strong evidence in favour of these claims has been further supported.

The leaf of the apple tree contains relatively large amounts of the substance identified with *p*-coumarylquinic acid and workers at Long Ashton have now isolated this substance and characterised it completely. There is no doubt as to its identification as *p*-coumarylquinic acid. The substance isolated from apple-leaf has been shown to be identical with the product obtained from tea in its chromatographic behaviour, absorption spectrum and chemical reactions. There is therefore little doubt that this substance in tea was correctly identified as *p*-coumarylquinic acid.

The position with regard to theogallin is even more definite. Further quantities of theogallin were prepared and it was established beyond doubt that gallic and quinic acids were produced on hydrolysis. The gallic and quinic acids were isolated and fully characterised, by analysis, mixed melting point, by preparation of typical derivatives, and, in the case of quinic acid, by X-ray diffraction patterns. It has also been shown that theogallin must be a mono-galloyl ester of quinic acid but the site of attachment remains to be established. It may be regarded as probable that theogallin is the 3-galloylquinic acid.

Substances IR and IC :

Progress into the elucidation of the nature of these two compounds has been disappointing, largely owing to the difficulties in obtaining them free from other tea polyphenols.

Carotenoids of tea :

In collaboration with Dr. Friend of the Low Temperature Research Station, Cambridge, a preliminary study was made of the carotenoids of green leaf, and in black tea manufactured from the same green leaf. The results of analyses of green leaf and black tea are given in table 8.

The most probable explanation of the lower figures obtained for black tea is that the carotenoids were oxidized during fermentation. Oxidation of carotenoids is known to yield a wide range of unsaturated aldehydes, so that carotenoid oxidation products may account in part for the volatile substances responsible for aroma.

Table 8.

	Green leaf	Black tea.
β-Carotene	116 p.p.m.	20.5 p.p.m.
α-Carotene (?)	16 p.p.m.	1.7 p.p m.
Lutein ...	123 p.p.m.	46.5 p.p.m.
Violaxanthin (?)	5 p.p.m.	1.3 p.p.m.
Unidentified xanthophylls ...	12 p.p.m.	5 p.p.m.

Pectins :

A method which estimates pectins as polyuronides was employed instead of the usual method which determines pectins as calcium pectate. For a black tea the total pectin content was found to be 6.20% of which 2.57% was water-soluble. This may be compared with the values for water-soluble pectins, ranging from 2.2 to 5.1%, obtained at Tocklai by the calcium pectate method.

PUBLICATIONS

Papers were read to the Food Group of the Society of Chemical Industry, and to the International Biochemical Congress at Vienna. The former was later published in the Journal of the Science of Food and Agriculture, **9**, 381, under the title of "The Chemistry of Tea Manufacture".

Other scientific papers published during 1958 included Roberts, E. A. H. and Oldschool, M., Enzymic Oxidations of Polyphenols to Benzotropolones, Chem. & Ind., p. 99.

Roberts, E. A. H., The Phenolic Substances of Manufactured Tea II—Their Origin as Enzymic Oxidation Products in Fermentation. J. Sci. Fd. Agric., **9**, 212.

Roberts, E. A, H. and Williams, D. M., The Phenolic Substances of Manufactured Tea III—Ultra-violet and Visible Absorption Spectra. J. Sci. Fd. Agric., **9**, 217.

Roberts, E. A. H., Wight, W. and Wood, D. J., Paper Chromatography as an Aid to the Taxonomy of Thea Camellias, New Phytol., **57**, 211.

Roberts, E. A. H. and Myers, M., Theogallin, a Polyphenol Occurring in Tea. II—Identification as Galloylquinic acid. J. Sci. Fd. Agric., **9**, 701.